STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS ROCKY FLATS PLANT SITE

Task 6
of the
Zero-Offsite Water-Discharge Study

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DISCLAIMER

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EXECUTIVE SUMMARY

This report is prepared for one of a number of studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle between the Colorado Department of Health (CDH) and the U.S. Department of Energy (DOE) (ASI, 1990a). The CDH/DOE Agreement Item C.7 states " Source Reduction and Zero Discharges Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review." This report addresses peak discharge and volume of water for various storm frequencies at the RFP.

If storm runoff is to be captured from the controlled area and/or parts of the buffer zone at the RFP, a decision is necessary as to the design storm-frequency precipitation event for which hydraulic structures would be designed. Specifically, this report presents analyses of storm runoff for several precipitation scenarios (ASI, 1990b). Four storm-frequency events were selected for study. They include the 25-year, 100-year, 500-year and Probable Maximum Precipitation (PMP) events. Storm duration and intensity are critical factors in estimating flood peaks and volumes of runoff. The 6-hour, 24-hour and 72-hour (3-day) duration events were analyzed for each of the four event frequencies previously stated. Additionally, the 1-hour duration local-storm PMP was analyzed. The 25-, 100- and 500-year recurrence intervals and the PMP were selected for analysis, partly because jurisdictional agencies (DOE and the State of Colorado) consider these events for design and regulatory purposes (DOE, 1989a, DOE, 1989b; Colorado State Engineer, 1988). Similarly, the 6-, 24- and 72-hour storm-event durations were selected in order to correspond with jurisdictional agencies' design and regulatory criteria. Storm recurrence intervals and durations also were selected to provide a wide range of alternatives for decision-making purposes.

The areal extent of this study includes the Walnut Creek watershed from west of the RFP (including flood flows contributed by Coal Creek) to and including Great Western Reservoir, which is located east of the RFP and its buffer zone. Also included in the study area is the Woman Creek watershed from west of the RFP (also including flood flows contributed by Coal Creek) to Indiana Street. Land-use conditions and surface-water conveyance and containment structures were assumed to be as they presently exist. Possible future land development and construction of diversion ditches or storage facilities are considered in other studies of the Zero-Offsite Water-Discharge Plan (ASI, 1990c and ASI, 1990d).

Woman Creek flows easterly across the southern and central areas of the RFP (Hurr, 1976). It is augmented by water diverted from Coal Creek through the Kinnear Ditch. Flow in Woman Creek is also augmented with Coal Creek water diverted through the Last Chance Ditch and Smart Ditch. However, these ditches flow in an easterly direction south of the developed areas of the RFP. These ditches join Woman Creek east of the RFP near Indiana Street. The South Interceptor Ditch prevents water running off from the developed areas of the RFP in the Woman Creek watershed from entering Woman Creek for all but floods greater than the 100-year event. Instead, the ditch routes this runoff to off-channel Pond C-2. The Woman Creek Diversion Dam routes Woman Creek/Kinnear Ditch flows around Pond C-2 through the Woman Creek Bypass Ditch. Downstream from the RFP, Woman Creek flows into Standley Lake, a source of municipal water for the cities of Westminster, Thornton and Northglenn.

The Walnut Creek watershed has two major tributaries, North Walnut Creek and South Walnut Creek, in the area of the RFP. These tributaries join in the buffer zone east of the RFP to form Walnut Creek. Hence, in this report, the Walnut Creek branches upstream from their confluence are referred to as North Walnut Creek and South Walnut Creek, respectively. Downstream from the confluence of North Walnut Creek and South Walnut Creek, the stream is referred to as Walnut Creek.

North Walnut Creek and South Walnut Creek flow in a northeasterly direction through the central and northern areas of the RFP. North Walnut Creek's flow is augmented by water diverted from Coal Creek through the Upper Church and McKay (also known as Zang) ditches. At the North Walnut Creek Diversion Dam, flow through the McKay and Upper Church ditches, along with runoff from the drainage area upstream from that point and flow in the West Interceptor Ditch, is routed to the McKay Bypass Ditch. The McKay Bypass Ditch flows to the north of the RFP, and it rejoins Walnut Creek east of the RFP and west of Indiana Avenue. The Upper Church Ditch is adjacent to the McKay Bypass Ditch, and, therefore, does not flow through the developed areas of the RFP. Under non-flood conditions, most of the Upper Church Ditch's flow is routed to Upper Church Lake, northeast of the RFP, and some flow may be redirected into Walnut Creek east of the RFP. Downstream from the RFP, Walnut Creek flows into Great Western Reservoir, a source of municipal water for the City of Broomfield.

East of the RFP, in the buffer zone, two small tributaries flow easterly towards Great Western Reservoir and Standley Lake. The drainage delineation between these small watersheds approximates the course of the access road which runs east-west and is located between Indiana Avenue and the RFP.

The Soil Conservation Service (SCS) computer model, TR-20 (SCS, 1983), was used to simulate flow at the RFP and to estimate flood-peak discharge rates and storm-runoff volumes. This model is appropriate for use at the RFP, because it permits hydrologic analysis of watersheds with various combinations of land cover and use. It also allows consideration of watersheds which have structural or channel modifications, such as the ponds and ditches currently existing at the RFP. Also, DOE (1989) specifies use of SCS techniques to determine runoff rates.

It was judged that Coal Creek will contribute runoff during storm events of 25-year recurrence interval and greater to North Walnut Creek and Woman Creek by spilling water into the Upper Church, McKay and Kinnear irrigation ditches. It was also judged, based on field observation and study of topographic maps, that the contribution of storm runoff from Coal Creek would be limited by the carrying capacities of these three ditches, because flood flows in excess of the ditches' capacities would remain in the Coal Creek drainage basin. According to Colorado State Engineer's files, their rated capacities are 18 cubic feet per second (cfs), 125 cfs and 780 cfs for Upper Church Ditch, McKay Ditch and Kinnear Ditch, respectively. However, field observations of ditch cross sections revealed that these ditches may be able to carry up to 94 cfs, 170 cfs and 1,600 cfs, respectively, into the RFP watersheds. The values estimated by field observation were used in TR-20 model simulations. Also, Coal Creek's storm runoff and peak flows were simulated for the storm frequencies and durations previously stated using the SCS model TR-20.

It was estimated by a previous study (McCall-Ellingson, 1978) that the South Boulder Diversion Canal can carry 3,200 cfs when flowing completely full. In their judgment, this canal would fail during PMP events, yielding a peak discharge of 3,200 cfs to Woman Creek and 1,100 cfs to North Walnut Creek. These peak-flow estimates were added to the peak flows within these basins estimated by the TR-20 program for 6-, 24- and 72-hour duration PMP events.

Storm runoff into and through Ponds A-4, B-5 and C-2 was analyzed using the TR-20 model for conditions where the ponds were empty, one-half full and full, respectively, at the beginning of the precipitation events. The carrying or diversion capacities of the North Walnut Creek Diversion Dam, the McKay Bypass Ditch, the Landfill North and South Interceptor Ditches, the South Interceptor Ditch, and the Woman Creek Diversion Dam were considered during this study. Channel hydraulic characteristics and pond-capacity ratings were obtained from as-built specifications presented in McCall-Ellingson (1978).

A summary of storms during which the capacity of RFP surface-water conveyance and Storage structures would be exceeded is presented in Table ES-1.

TABLE ES-1

STORMS DURING WHICH THE CAPACITY OF RFP SURFACE-WATER CONVEYANCE AND STORAGE STRUCTURES WOULD BE EXCEEDED

STRUCTURE	STORM RECURRENCE INTERVAL									PMP			
	25-YEAR			100-YEAR			500-YEAR						
	DURATION			DURATION			DURATION			DURATION			
	6-hr	24-hr	72-hr	6-hr	24-hr	72-hr	6-hr	24-hr	72-hr	1-hr	6-hr	24-hr	72-hr
N. Walnut Cr. Diversion Dam		●	●	●	●	●	●	●	●	●	●	●	●
McKay Bypass - Reach 1												●	●
McKay Bypass - Reach 2										●	●	●	●
McKay Bypass - Reach 3										●	●	●	●
McKay Bypass - Reach 4													
Landfill S. Interceptor Ditch												●	●
Landfill N. Interceptor Ditch										●	●	●	●
Woman Cr. Diversion Dam		●	●	●	●	●	●	●	●	●	●	●	●
South Interceptor - Reach 1								●	●	●	●	●	●
South Interceptor - Reach 2										●	●	●	●
South Interceptor - Reach 3										●	●	●	●
South Interceptor - Reach 4										●	●	●	●
Pond A-4 - empty			●		●	●	●	●	●	●	●	●	●
Pond B-5 - empty			●		●	●	●	●	●	●	●	●	●
Pond C-2 - empty					●	●	●	●	●	●	●	●	●
Pond A-4 - half full		●	●	●	●	●	●	●	●	●	●	●	●
Pond B-5 - half full	●	●	●	●	●	●	●	●	●	●	●	●	●
Pond C-2 - half full		●	●	●	●	●	●	●	●	●	●	●	●
Great Western Res. spillway										●	●	●	●

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Rocky Flats Plant Site

1.0 INTRODUCTION

This report is prepared for one of a number studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle between the Colorado Department of Health (CDH) and the U.S. Department of Energy (DOE) (ASI, 1990a). The CDH/DOE Agreement Item C.7 states " Source Reduction and Zero Discharges Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review." This report addresses zero discharge of water at the RFP.

If storm runoff is to be captured from the controlled area and/or parts of the buffer zone at the RFP, a decision is necessary as to the design precipitation event for which hydraulic structures would be designed. Specifically, this report presents analyses of storm runoff for several precipitation scenarios (ASI, 1990b). Four storm-frequency events were selected for study. They include the 25-year, 100-year, 500-year and Probable Maximum Precipitation (PMP) events. Storm duration and intensity are critical factors in estimating flood peaks and volumes of runoff. The 6-hour, 24-hour and 72-hour (3-day) duration events were analyzed for each of the four event frequencies previously stated. Additionally, the 1-hour duration local-storm PMP was analyzed. The 25-, 100- and 500-year recurrence intervals and the PMP were selected for analysis, partly because jurisdictional agencies (DOE and the State of Colorado) consider these events for design and regulatory purposes (DOE, 1989a, DOE, 1989b; Colorado State Engineer, 1988). Similarly, the 6-, 24- and 72-hour durations were selected in order to correspond with jurisdictional agencies' design and regulatory criteria. Storm recurrence intervals and durations also were selected to provide a wide range of alternatives for decision-making purposes.

The RFP is drained primarily by the Walnut Creek and Woman Creek watersheds. North and South Walnut Creeks join in the buffer zone east of the RFP to form the mainstem Walnut Creek (Figure 3). Hence, in this report, the mainstem Walnut Creek major upstream tributaries are referred to as North and South Walnut Creeks, respectively. Downstream from the confluence of North and South Walnut Creeks, the stream is referred to as Walnut Creek. Flow in North Walnut Creek is augmented by water diverted from Coal Creek into the Upper Church and McKay Ditches (Figure 3). Woman Creek's flow in the RFP area is augmented by Coal Creek water diverted through Kinnear Ditch. South Boulder Diversion Canal transports water in a southerly direction from South Boulder Creek to Ralston Reservoir. The route of this canal is immediately west of the RFP (Figure 3).

The areal extent of this study includes the Walnut Creek watershed from west of the RFP (including flood flows contributed by Coal Creek) to and including Great Western Reservoir, which is located east of the RFP and its buffer zone. Also included in the study area is the Woman Creek watershed from west of the RFP (also including flood flows contributed by Coal Creek) to Indiana Street. Land-use conditions and surface-water conveyance and containment structures were assumed to be as they presently exist. Possible future land development and construction of diversion ditches or storage facilities are considered in other studies of the Zero-Offsite Water-Discharge Plan (ASI, 1990c and ASI, 1990d).

Definitions of several important words and phrases used in this report are given in Appendix A.

2.0 PRECIPITATION

The frequency or probability of occurrence of a rainfall event, its duration and intensity are all important factors in estimating flood peaks and runoff volumes. Point precipitation values were obtained for recurrence intervals from 2 years through the 100-year event, and for storm durations of 1 hour, 6 hours and 24 hours from Miller, Frederick and Tracey (1973). Values of 500-year precipitation events were estimated by extrapolation from log-log plots of 2-year through 100-year rainfall amounts (Figure 1). Similarly, 72-hour precipitation amounts were obtained by extrapolating log-log plots of 1-hour, 6-hour and 24-hour events (Figure 2).

PMP values were obtained from isohyetal maps presented in Hansen and others (1988). Hansen analyzed climatologic conditions and historical storms in the specific longitudinal regime in which the RFP is located in order to develop the isohyetal maps. In addition to the 6-, 24-, and 72-hour PMP values for general storms, the 1-hour local PMP was analyzed during this study. The local storm differs from the general storm in cause, duration and areal extent. It is not part of a frontal or other general storm system, but arises locally as a result of convective forces. Its duration is quite short, generally one hour or less, and its areal extent is usually limited to approximately one square mile. Table 1 presents rainfall amounts for storm recurrence intervals and durations used during this study and other storm recurrence intervals and durations of potential interest.

The magnitude of flood-peak flows and runoff volume depends on the temporal distribution of rainfall as well as the amount of rainfall and the storm duration. In the Denver region, a technique for estimating the 2-hour design-storm distribution was presented in a study done for the Denver Regional Council of Governments (DRCOG) (Urban Drainage and Flood Control District, 1969, with updates). This distribution was adjusted using the techniques suggested in the DRCOG document to develop the 6-hour precipitation distributions used during this study (

Appendix B, Table B-1).

Table 1
Precipitation Values for the RFP
(in inches)

	RECURRENCE INTERVAL (Probability of Occurrence)									REFERENCE
DURATION	2-yr (50%)	5-yr (20%)	10-yr (10%)	25-yr (4%)	50-yr (2%)	100-yr (1%)	500 yr (0.2%)	PMP(L)	PMP(G)	APPENDIX TABLE
5-min	0.3	0.4	0.5	0.6	0.7	0.8	--	--	--	
10-min	0.5	0.6	0.8	1.0	1.1	1.2	--	--	--	
15-min	0.6	0.8	1.0	1.2	1.4	1.5	--	--	--	
30-min	0.8	1.2	1.4	1.7	1.9	2.1	--	--	--	
1-hr	1.0	1.5	1.8	2.1	2.4	2.7	3.3	10.7	13	B-4
2-hr	1.2	1.6	2.0	2.4	2.8	3.0	3.8	--	15	
6-hr	1.6	2.0	2.5	3.0	3.4	3.8	4.8	14.5	24	B-1
24-hr	2.2	2.8	3.2	4.0	4.4	5.2	6.5	--	35	B-2
72-hr	2.9	3.3	3.8	5.0	5.5	6.3	8.1	--	43	B-3

PMP(L) = Local Storm PMP

PMP(G) = General Storm PMP

Table 1 (con't.)
Precipitation Values for the RFP
(in inches)

For 2-yr through 500-yr recurrence-interval storms:

5-min, 10-min, 15-min and 30-min duration values from SC-109 (DOE, 1986).

1-hr, 6-hr and 24-hr duration values from NOAA Atlas 2 (Miller, Frederick and Tracey, 1973).

72-hr duration values extrapolated from log-log plot of 1-hr to 24-hr duration values (Miller, Frederick and Tracey, 1973) (Figure 2).

500-yr values extrapolated from log-log plot of 2-yr to 100-yr values (Miller, Frederick and Tracey, 1973) (Figure 1).

PMPs from National Weather Service HMR-55A (Hansen and others, 1988).

Rainfall intensity (in/hr) = (Precipitation (in) * 60) / Duration (min).

The U.S. Department of Agriculture's Soil Conservation Service (SCS) developed a design-storm distribution for the 24-hour rainfall event (SCS, 1983; Haan and Barfield, 1978) (Appendix B, Table B-2). This Type II design storm was developed for use in the western United States. The SCS distribution was used in this study for all 24-hour storm analyses. The 72-hour duration storm distribution was developed by using the same values estimated for the 24-hour event for the first 24 hours. Thereafter, the difference between the 72-hour and 24-hour totals was distributed uniformly for the remainder of the 72-hour period (see Appendix B, Table B-3).

Appendix B, Table B-4 contains the local-storm PMP rainfall distribution assumed for the purposes of this study.

3.0 FLOOD-FLOW ANALYSIS

3.1 FLOOD-FLOW MODELING TECHNIQUE

3.1.1 SCS TR-20 Program

The SCS has developed a computer program, TR-20, which provides hydrologic analyses of a watershed's flood-flow response under various conditions (SCS, 1983). This model is appropriate for use at the RFP, because it permits hydrologic analysis of watersheds with various combinations of land cover and use. It also allows consideration of watersheds which have structural or channel modifications, such as the ponds and ditches currently existing at the RFP. In its design criteria manual, DOE (1989) specifies that SCS techniques shall be used to determine runoff rates. The TR-20 program was used in a previous study of storm runoff at the RFP (Lee Wan, 1987). That previous study analyzed storm runoff principally for the 25-year, 1-hour duration event. The focus of the current study was to define storm-runoff potential at the RFP on a larger scale and for longer recurrence-interval and duration storm events. Previous flood analyses at the RFP are discussed in Section 4.0 of this report. Appendix E presents an example printout of the input file to a TR-20 model simulation run used during this study.

3.1.2 Watershed Description

The watersheds of interest at the RFP for the purposes of this study are the Woman Creek and Walnut Creek basins (Figure 3). Woman Creek flows easterly across the southern and central areas of the RFP (Hurr, 1976). It is augmented by water diverted from Coal Creek through the Kinnear Ditch. Flow in Woman Creek is also augmented with Coal Creek water diverted through the Last Chance Ditch and Smart Ditch. However, these ditches flow in an easterly direction south of the developed areas of the RFP. These ditches join Woman Creek east of the RFP near Indiana Street. The South Interceptor Ditch prevents water running off from the developed areas of the RFP in the Woman Creek watershed from entering Woman Creek for all but floods greater than the 100-year event. Instead, the ditch routes this runoff to off-channel Pond C-2 (Figure 3). The Woman Creek Diversion Dam routes Woman Creek/Kinnear Ditch flows around Pond C-2 through the Woman Creek Bypass Ditch. Downstream from the RFP, Woman Creek flows into Standley Lake, a source of municipal water for the cities of Westminster, Thornton and Northglenn. According to Arber Associates (1984), Woman Creek and Kinnear Ditch supply approximately 16 percent of Standley Lake's average annual inflow (ASI, 1990e).

The Walnut Creek watershed has two major tributaries, North Walnut Creek and South Walnut Creek, in the area of the RFP. These tributaries join in the buffer zone east of the RFP to form Walnut Creek. Hence, in this report, the Walnut Creek branches upstream from their confluence are referred to as North Walnut Creek and South Walnut Creek, respectively. Downstream from the confluence of North Walnut Creek and South Walnut Creek, the stream is referred to as Walnut Creek.

North Walnut Creek and South Walnut Creek flow in a northeasterly direction through the central and northern areas of the RFP. North Walnut Creek's flow is augmented by water diverted from Coal Creek through the Upper Church and McKay (also known as Zang) ditches. At the North Walnut Creek Diversion Dam, flow through the McKay and Upper Church ditches, along with runoff from the drainage area upstream from that point and flow in the West Interceptor Ditch, is routed to the McKay Bypass Ditch. The McKay Bypass Ditch flows to the north of the RFP, and it rejoins Walnut Creek east of the RFP and west of Indiana Avenue (Figure 3). The Upper Church Ditch is adjacent to the McKay Bypass Ditch, and, therefore, does not flow through the developed area of the RFP. However, the Upper Church Ditch is not designed to carry large flood flows, and, for the purposes of this study, it was assumed that it would not contain the storm runoff from 25-year and larger magnitude flood events. Therefore, it was assumed that this ditch would overflow into the North Walnut Creek watershed. Under non-flood conditions, most of the Upper Church Ditch's flow is routed to Upper Church Lake, northeast of the RFP, and some flow is redirected into Walnut Creek east of the RFP. Downstream from the RFP, Walnut Creek flows into Great Western Reservoir, a source of municipal water for the City of

Broomfield. According to City of Broomfield records, approximately 25 percent of Great Western Reservoir's average annual yield is from the Walnut Creek watershed (ASI, 1990e).

East of the RFP, in the buffer zone, two small tributaries flow easterly towards Great Western Reservoir and Standley Lake. The drainage delineation between these small watersheds approximates the course of the access road which runs east-west and is located between Indiana Avenue and the RFP.

In order to estimate flood-peak flows and runoff volumes at selected locations, the Woman Creek and Walnut Creek watersheds were divided into subbasins as shown on Figure 4. The subbasin division was developed to facilitate estimation of peak flows and volumes at locations of interest. Consideration of the carrying and diversion capacities of the RFP diversion and ditch structures was also part of the scope of this investigation. Therefore, subbasin division was also developed to facilitate peak-flow and flood-volume simulation of the various ditch reaches. The selected locations are listed and described on Table 2. Several of these locations coincide with EG&G surface-water (SW) collection sites (EG&G, 1990). Table 2 presents the SW site designations where applicable.

Table 2
Flood-Peak and Storm-Runoff Sites at the RFP

EG&G SAMPLE SITE[1]	CURRENT STUDY SITE[2]	DESCRIPTION
--	1	Coal Creek near Plainview (discontinued USGS gage site 06730300)
		WALNUT CREEK
SW-7	2	Upper Church/McKay Ditches at S. Boulder Div. Canal
SW-9	3	N. Walnut Cr. at N. Walnut Cr. Diversion Dam
--	4	McKay Bypass Ditch, end of Reach 1
--	5	McKay Bypass Ditch, end of Reach 2
SW-12	6	McKay Bypass Ditch, end of Reach 3
--	7	McKay Bypass Ditch, end of Reach 4
--	8	Landfill South Interceptor Ditch
--	9	Landfill North Interceptor Ditch
SW-98	10	Landfill Reservoir
SW-15	11	Landfill Reservoir subbasin outlet
--	12	Inflow to Pond A-4
SW-16	13	Outlet of Pond A-4
--	14	Inflow to Pond B-5
SW-25	15	Outlet of Pond B-5
--	16	Confluence of N. Walnut & S. Walnut Creeks
SW-3	17	Walnut Creek at Indiana Street
--	18	Great Western Reservoir Trib. at Indiana Street
--	19	Inflow to Great Western Reservoir
--	20	Outlet of Great Western Reservoir
		WOMAN CREEK
SW-42	21	Woman Creek/Kinnear Ditch at S. Boulder Div. Canal
SW-36	22	South Interceptor Ditch, end of Reach 1
SW-71	23	South Interceptor Ditch, end of Reach 2
--	24	South Interceptor Ditch, end of Reach 3
SW-63	25	South Interceptor Ditch, end of Reach 4
SW-62	26	Woman Cr. at Woman Creek Diversion Dam
SW-27	27	Woman Creek Bypass Ditch
--	28	Inflow to Pond C-2
SW-26	29	Outflow of Pond C-2
SW-1	30	Woman Creek at Indiana Street
--	31	Standley Lake Tributary at Indiana Avenue

1 Site number refers to EG&G (1990) surface-water sample-collection site
2 Site number refers to locations shown on Figure 4.

3.1.3 Basin Characteristics and Model Input

The SCS TR-20 program requires the input of several basin characteristics, including drainage area, time of concentration (Tc) and SCS runoff curve number (CN). The antecedent moisture condition (AMC), associated with the precipitation amount in the 5-day period preceding a given storm of interest, is also an input parameter to TR-20. AMC I assumes dry conditions during the 5-day period preceding the storm of interest, AMC II assumes average conditions, and AMC III assumes wet conditions. Drainage area was planimetered from available 1 in = 2,000 ft and 1 in = 500 ft topographic maps. Tc was estimated using the modified curve-number method (SCS, 1975). This method relates lag (L), the time from the center of mass of excess rainfall to the peak rate of runoff, to Tc. Lag is computed as a function of the hydraulic length of the watershed, CN and average watershed land slope. The modified curve-number method was judged appropriate for use at the RFP because it is an SCS technique and is therefore consistent with the SCS TR-20 model.

The concept of runoff-curve numbers was developed by SCS to permit estimation of the relative amount of a rain event that would run off rather than be retained in the basin. Therefore, CN is a function of soil or land perviousness, AMC and the amount of rainfall intercepted by vegetation or structures. Soil or land perviousness is, in part, a function of land use and development. Runoff-curve numbers theoretically can range from zero (infinite retention and infiltration capacity) to 100 (no retention and infiltration capacity). In practice, values range from 40 or 50 for well drained soils up to 98 for developed impervious areas (pavement, etc.).

Based on drainage basin geometry and soil type, weighted curve numbers were estimated for each of the 15 subbasins analyzed during this study, these weighted curve numbers and their corresponding drainage basins are presented in Table 3. Subbasins, which were further divided because of ditch hydraulic characteristics, were not further subdivided for curve-number analysis. For each subbasin, the relative amounts of hydrologic soil types A through D were estimated by planimetering soil maps (SCS, 1980). Infiltration characteristics of soil types A through D are described as follows:

A - Low runoff potential. Soils have high infiltration rates even when thoroughly wetted.

B - Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately fine to moderately coarse textures.

C - Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture.

D - High runoff potential. Soils having very slow infiltration rates when thoroughly wetted.

Table 3
Curve-Number[1] Analysis for RFP Subbasins.

		HYDROLOGIC SOIL GROUP[2]										
		B (CN = 62)		C-D (CN = 80)		D (CN = 85)		C (CN = 74)		IMPERVIOUS (CN = 98)		
DRAINAGE BASIN[3]	BASIN AREA (mi^2)	(mi^2)	(%)	(mi^2)	(%)	(mi^2)	(%)	(mi^2)	(%)	(mi^2)	(%)	WEIGHTED CURVE NUMBER[4]
1 Walnut Creek/Indiana	0.69	0.09	13	0.35	51	0.01	1	0.24	35	0	0	76
2 McKay Bypass	0.43	0.01	20	0	2	0	0	0.42	98	0	0	74
3 Landfill Reservoir	0.49	0.01	1	0.22	45	0	0	0.26	52	0.01	2	77
4 S.Walnut Cr. down-stream from Pond B-5	0.08	0.02	25	0.04	50	0	0	0.02	25	0	0	74
5 N.Walnut Creek-Pond A-4	0.60	0.07	12	0.19	32	0	0	0.18	30	0.16	27	81
6 S.Walnut Creek-Pond B-5	0.50	0.03	6	0.1	20	0	0	0.11	22	0.26	52	87
7 Upper N. Walnut Creek	0.54	0.03	6	0	0	0	0	0.45	80	0.06	11	76
8 Woman Creek at Indiana	0.76	0.15	20	0.16	21	0	0	0.45	59	0	0	73
9 S. Interceptor-Pond-C-2	0.32	0.03	9	0.17	53	0	0	0.11	34	0.01	3	77
10 Woman Creek	1.42	0.31	22	0.14	10	0	0	0.97	68	0	0	72
11 Upper Woman Creek	0.59	0.04	7	0.03	5	0	0	0.52	88	0	0	73
12 Great Western Reservoir Tributary No. 1	0.35	0.02	6	0.16	46	0.02	6	0.15	43	0	0	77
13 Standley Lake Trib.	0.26	0.01	4	0.04	15	0	0	0.21	81	0	0	74
14 Great Western Reservoir Tributary No. 2	0.17	0.02	12	0	0	0	0	0.15	88	0	0	73
15 Great Western Reservoir East of Indiana St.	1.25	0.03	2	0.33	26	0.02	2	0.68	54	0.19	15	79

1 Curve Numbers taken from SCS, TR-55 (1986), Table 2-2d. Runoff Curve Numbers for arid and semiarid rangelands.
Cover type: Herbaceous - mixture of grass, weeds and low-growing brush.
Condition: Good (> 70% ground cover).

2 Soil Types taken from SCS (1980), Soil Survey of Golden Area.

3 Drainage-basin number refers to subbasins shown on Figure 4.

4 WEIGHTED CURVE NO. = ((% Type B * 62) + (% Type C * 74) + (% Type C-D * 80) + (% Type D * 85) + (% Impervious * 98))/ 100

At the RFP, no soils of hydrologic type A are present. The predominant hydrologic soil type is C. Curve numbers are given for each hydrologic soil type for various land-use designations in SCS (1986). At the RFP, in undeveloped areas, the land-use characteristics fall in the category of arid and semi-arid rangelands in good condition (greater than 70 percent ground cover), with vegetation consisting of a mixture of grass, weeds and low-growing brush. The overall effective curve numbers given in SCS (1986) for the hydrologic soil types with the described land use and cover conditions in the RFP area are as follows: B - 62, C - 74, and D - 85.

At the RFP, several of the soil classifications are a combination of hydrologic soil types C and D, and are categorized as C-D. Accordingly, a curve number of 80 was assigned to these soils. Percent impervious area was estimated at the RFP from available maps and color-infrared aerial photography, coupled with a field reconnaissance. A curve number of 98 was assigned to these areas. Table 3 summarizes the curve-number analysis completed for the RFP subbasins. For analysis of the 25-, 100- and 500-year events, average antecedent moisture conditions (AMC II) were assumed. However, for the PMP events, worst-case conditions of AMC III were assumed. Table 4 lists basin characteristics, including weighted curve numbers, used as input to the TR-20 simulations for the subbasins shown on Figure 4.

3.2 FLOOD RUNOFF FROM COAL CREEK

It was previously discussed that water is diverted from Coal Creek into irrigation ditches that convey water through the RFP to Standley Lake and Great Western Reservoir, both municipal reservoirs. It is judged that, during storm events having recurrence intervals of 25 years or greater, flood runoff would spill from Coal Creek's stream channel into Upper Church, McKay and Kinnear ditches. The storm runoff thus spilled would travel through the RFP, and bypass- or diversion- ditch design should consider the amount of Coal Creek runoff as well as the runoff from the associated RFP contributing areas.

The judgment that Coal Creek extreme-event runoff would spill into diversion ditches was made as follows. First, flood flows for the Coal Creek basin at the discontinued U.S. Geological Survey (USGS)/Colorado State Engineer (SE) stream-gaging station 06730300 - Coal Creek near Plainview (Figure 4) were estimated using TR-20 (Table 5). Then, an analysis was performed to estimate the approximate discharge above which Coal Creek flow would spill into the ditches. The head gates for the Upper Church, McKay and Kinnear ditches are located within approximately one-half mile downstream from the discontinued USGS/SE gaging station. It was, therefore, assumed that flood-flow and channel characteristics at the head gates are comparable to those at the gaging station. The heights of the diversion-ditch head gates above the Coal Creek channel were measured. It was estimated that the minimum head-gate height corresponds to a stage at the USGS/SE gage of approximately 3 feet (ft). From a stage-discharge rating table, obtained from the State Engineer's office (Appendix C, Figure C-1), it was found that a stage of 3 ft corresponds to a stream discharge of approximately 600 cubic feet per second (cfs). Therefore, it is judged that Coal Creek streamflow exceeding 600 cfs would overflow water into the diversion ditches.

It is further judged, based on field observation and study of topographic maps, that the amount of Coal Creek storm runoff entering the RFP through the diversion ditches would be limited to the carrying capacity of the ditches. The amount of runoff exceeding the ditches' carrying capacities would remain in the Coal Creek basin. According to State Engineer records, the capacities of the diversion ditches are as follows:

Upper Church Ditch	- 18 cfs
McKay Ditch	- 125 cfs
Kinnear Ditch	- 780 cfs.

However, field measurement of channel cross sections of the three ditches near their head gates (Appendix C, Figure C-2) indicate that their carrying capacities may be as high as the following:

Upper Church Ditch	- 410 cfs
McKay Ditch	- 500 cfs
Kinnear Ditch	- 1,600 cfs.

Table 4
Basin Characteristics for RFP Subbasins

DRAINAGE BASIN[1]	BASIN AREA (mi^2)	BASIN HEIGHT (Z) (ft)	CHANNEL LENGTH (L) (ft)	CONTOUR LENGTH AT 25% OF BASIN SLOPE[2] (BS) (ft/ft)	CONTOUR LENGTH AT 50% OF BASIN HEIGHT (LC25) (ft)	CONTOUR LENGTH AT 75% OF AVERAGE BASIN HEIGHT (LC50 (ft)	BASIN HEIGHT (LC75) (ft)	BASIN SLOPE[3] (SBAR) (ft/ft)	WEIGHTED CURVE NUMBER (CN)	LAG[4] (hr)	TIME OF CONCENTRATION[5] (Tc) (hr)
1 Walnut Creek at Indiana	0.69	285	8,500	0.03	11,800	10,200	6,000	0.10	76	0.62	1.03
2 McKay Bypass	0.43	270	10,000	0.03	2,800	3,300	1,500	0.04	74	1.16	1.93
2a (McKay Bypass Subbasin)	0.03	55	2,800	0.02	500	600	350	0.02	74	0.56	0.93
2b (McKay Bypass Subbasin)	0.08	78	4,000	0.02	1,000	2,000	500	0.03	74	0.66	1.10
2c (McKay Bypass Subbasin)	0.14	90	5,500	0.02	1,500	3,300	550	0.03	74	0.85	1.41
2d (McKay Bypass Subbasin)	0.18	180	5,000	0.045	2,000	3,100	2,700	0.07	74	0.52	0.87
3 Landfill Reservoir Basin	0.49	340	10,000	0.03	3,300	7,000	5,200	0.10	77	0.71	1.18
3a (Landfill Reservoir	0.03	56	3,000	0.02	550	680	1,000	0.04	77	0.43	0.72
3b Subbasins)	0.03	72	3,800	0.02	400	360	600	0.03	77	0.59	0.99
3c (Landfill Reservoir	0.05	73	2,350	0.03	2,100	1,800	1,200	0.07	77	0.27	0.44
3d Subbasins)	0.38	325	9,900	0.03	3,000	7,300	4,050	0.11	77	0.66	1.09
4 S. Walnut Cr. downstream from Pond B-5	0.08	220	1,600	0.14	1,300	1,100	1,100	0.09	74	0.19	0.31
5 N.Walnut Creek-Pond A-4	0.60	320	10,500	0.03	4,000	6,700	3,600	0.07	81	0.77	1.29
6 S.Walnut Creek-Pond B-5	0.50	295	10,000	0.03	4,000	6,700	3,600	0.08	87	0.58	0.96
7 Upper N. Walnut Creek	0.54	165	7,000	0.02	3,300	3,000	1,900	0.02	76	1.13	1.89
8 Woman Creek at Indiana	0.76	325	5,800	0.06	9,200	4,100	2,500	0.06	73	0.65	1.08
9 S. Interceptor-Pond C-2	0.32	310	8,500	0.04	2,700	5,000	4,800	0.10	77	0.62	1.03
9a (S. Interceptor Ditch	0.05	104	2,500	0.04	1,850	2,100	1,550	0.10	77	0.23	0.38
9b Subbasins)	0.04	106	1,750	0.06	900	950	1,650	0.08	77	0.19	0.31
9c (S. Interceptor Ditch	0.03	126	1,800	0.07	1,150	1,100	1,000	0.12	77	0.16	0.27
9d Subbasins)	0.20	230	4,000	0.06	1,200	3,300	3,850	0.07	77	0.41	0.68
10 Woman Creek	1.42	480	16,200	0.03	7,000	8,000	9,000	0.07	72	1.38	2.30
11 Upper Woman Creek	0.59	310	9,500	0.03	3,800	2,800	1,700	0.04	73	1.20	1.99
12 Great Western Reservoir Tributary No. 1	0.35	265	5,200	0.05	4,800	3700	1,900	0.08	77	0.47	0.78
13 Standley Lake Trib.	0.26	215	4,500	0.05	4,100	2000	1,300	0.05	74	0.54	0.90
14 Great Western Reservoir Tributary No. 2	0.17	100	9,000	0.01	1,500	1200	650	0.02	73	1.70	2.84
15 Great Western Reservoir East of Indiana St.	1.25	240	6,000	0.04	15,000	10000	4,400	0.05	79	0.61	1.01

[1] Drainage-basin numbers refer to subbasins shown on Figure 4

[2] BS = Z/L

[3] SBAR = 0.25 Z (LC25 + LC50 + LC75)/ (Drainage Area, in ft^2) (SCS, 1977)

[4] LAG = $(L^{0.8} * (S+1)^{0.7}) / 1900 (SBAR*100)^{0.5}$ where: S = ((1000/CN)-10) (SCS, 1975)

[5] Tc = LAG / 0.6

Table 5
Estimated Peak Flows at Selected RFP Surface-Water Sites

PEAK FLOW, CFS

SITE NO.[5]	SITE DESCRIPTION	25-YEAR			100-YEAR			500-YEAR			PMP			
		6-HR	24-HR	72-HR[6]	6-HR	24-HR	72-HR[6]	6-HR	24-HR	72-HR[6]	1-HR	6-HR	24-HR	72-HR[6]
1	Coal Cr. @ USGS gage	790	2,000	2,000	1,900	4,400	4,400	3,600	7,600	7,600	--	74,000	120,000	120,000
2	Upper Church/McKay Ditches @ S. Boulder Diversion Canal	170	260	260	260	260	260	260	260	260	--	1,400	1,400	1,400
3	runoff to N. Walnut Creek Diversion Dam	240	430	430	440	550	550	530	680	680	1,900	3,800	3,700	3,700
	runoff to McKay Bypass, Reach 1, from N. Walnut Cr. Div. Dam	240	330	330	330	330	330	330	330	330	330	330	330	330
	amount spilled to N. Walnut Cr. from N. Walnut Cr. Div. Dam	0	100	100	110	220	220	200	350	350	1,500	3,400	3,400	3,400
4	McKay Bypass, Reach 1	240	340	340	340	350	350	340	360	360	510	550	640	640
	Amount spilled to Landfill S.Interceptor from McKay Bypass	0	0	0	0	0	0	0	0	0	0	0	77	77
5	McKay Bypass, Reach 2	240	350	350	350	380	380	380	430	430	930	1,100	1,300	1,300
	amount spilled to Landfill N. Interceptor from McKay Bypass	0	0	0	0	0	0	0	0	0	230	380	620	620
6	McKay Bypass, Reach 3	240	370	370	380	440	440	430	530	530	1,300	1,500	1,800	1,800
	amount spilled from McKay Bypass to Landfill Reservoir Basin	0	0	0	0	0	0	0	0	0	540	700	1,000	1,000
7	McKay Bypass, Reach 4	250	390	390	400	480	480	470	610	610	1,800	2,100	2,600	2,600
8	Landfill S.Interceptor	10	21	21	20	33	33	29	46	46	220	260	420	420
	amount spilled from Landfill S.Interceptor to Landfill Reservoir	0	0	0	0	0	0	0	0	0	0	0	100	100

Table 5 (Con't)
Estimated Peak Flows at Selected RFP Surface-Water Sites (continued)

SITE NO.[5]	SITE DESCRIPTION	PEAK FLOW, CFS 25-YEAR 6-HR	25-YEAR 24-HR	25-YEAR 72-HR[6]	100-YEAR 6-HR	100-YEAR 24-HR	100-YEAR 72-HR[6]	500-YEAR 6-HR	500-YEAR 24-HR	500-YEAR 72-HR[6]	PMP 1-HR	PMP 6-HR	PMP 24-HR	PMP 72-HR[6]
9	Landfill N.Interceptor	9	17	17	17	27	27	25	38	38	400	590	910	910
	amount spilled from Landfill N. Interceptor to Landfill Reservoir	0	0	0	0	0	0	0	0	0	82	270	590	590
	runoff to Landfill Reservoir	20	45	45	42	69	69	63	98	98	490	590	1,100	1,100
10	Landfill Reservoir	0	1	1	<1	7	7	7	24	24	240	380	740	740
11	outflow from Landfill Reservoir Basin	120	240	240	230	370	370	340	540	540	3,200	4,000	5,800	5,800
12	runoff to Pond A-4	200	340	340	350	550	550	520	860	860	3,900	6,400	7,600	7,600
13	outflow - Pond A-4[1]	0	0	7	0	100	100	94	430	430	--	--	--	--
	[2]	0	110	110	120	380	380	330	800	800	--	--	--	--
	[3]	170	290	290	300	500	500	470	860	860	3,800	6,400	7,500	7,500
14	runoff to Pond B-5	280	440	440	480	620	620	640	820	820	3,200	3,900	5,100	5,100
15	outflow - Pond B-5[1]	0	0	6	0	44	44	74	210	210	--	--	--	--
	[2]	39	100	100	110	370	370	270	710	710	--	--	--	--
	[3]	250	410	410	450	610	610	630	800	800	3,000	3,700	4,900	4,900
16	confluence of N. & [1]	130	260	260	250	400	400	370	740	740	--	--	--	--
	S. Walnut Cr. & [2]	130	260	260	250	700	700	630	1,500	1,500	--	--	--	--
	Landfill Res. Basin[3]	520	880	880	920	1,300	1,300	1,300	2,000	2,000	9,600	14,000	18,000	18,000
17	Walnut Cr. at[1]	390	770	770	770	1,200	1,200	1,100	1,800	1,800	--	--	--	--
	Indiana St. [2]	390	770	770	770	1,400	1,400	1,300	2,500	2,500	--	--	--	--
	[3]	780	1,400	1,400	1,400	2,200	2,200	2,100	3,200	3,200	15,000	20,000	27,000	27,000
18	Great Western Res. Trib. @ Indiana	110	230	230	220	360	360	330	510	510	2,400	2,900	4,000	4,000
19	runoff to Great [1]	860	1,700	1,700	1,700	2,700	2,700	2,500	3,800	3,800	--	--	--	--
	Western Reservoir[2]	860	1,700	1,700	1,700	2,700	2,700	2,500	4,100	4,100	--	--	--	--
	[3]	1,200	2,200	2,200	2,300	3,500	3,500	3,300	4,900	4,900	24,000	30,000	42,000	42,000

Table 5 (Con't.)
Estimated Peak Flows at Selected RFP Surface-Water Sites (continued)

PEAK FLOW, CFS

SITE NO.[5]	SITE DESCRIPTION	25-YEAR			100-YEAR			500-YEAR			PMP			
		6-HR	24-HR	72-HR[6]	6-HR	24-HR	72-HR[6]	6-HR	24-HR	72-HR[6]	1-HR	6-HR	24-HR	72-HR[6]
20	outflow from Great Western Reservoir [1]	0	0	0	0	0	34	0	76	94	--	--	--	--
	[2]	0	0	0	0	0	48	0	100	100	--	--	--	--
	[3]	0	0	0	0	9	56	0	120	120	7,200	21,000	41,000	41,000
	[4]	110	160	160	180	360	360	400	690	700	20,000	25,000	39,000	39,000
	Coal Cr. flow to Kinnear Ditch	0	1,200	1,200	1,100	1,600	1,600	1,600	1,600	1,600	--	1,600	1,600	1,600
21	Woman Cr. & Kinnear Ditch @ S. Boulder Diversion Canal	91	1,300	1,300	1,200	1,900	1,900	1,900	2,000	2,000	1,900	7,300	8,400	8,400
22	S. Interceptor Ditch, Reach 1	22	47	47	45	74	74	67	100	100	530	640	780	780
	amount spilled to Woman Cr. from S. Interceptor, Reach 1	0	0	0	0	0	0	0	3	3	430	540	680	680
23	S. Interceptor Ditch, Reach 2	34	79	79	73	120	120	110	180	180	560	660	750	750
	amount spilled to Woman Cr. from S. Interceptor, Reach 2	0	0	0	0	0	0	0	0	0	320	420	510	510
24	S. Interceptor, Reach 3	43	98	98	92	160	160	140	230	230	610	690	740	740
	amount spilled to Woman Cr. from S. Interceptor, Reach 3	0	0	0	0	0	0	0	0	0	260	340	390	390
25	S. Interceptor, Reach 4	100	220	220	210	360	360	320	510	510	1,900	2,500	3,300	3,300
	amount spilled to Woman Cr. from S. Interceptor, Reach 4	0	0	0	0	0	0	0	0	0	1,200	1,900	2,600	2,600

Table 5 (Con't.)
Estimated Peak Flows at Selected RFP Surface-Water Sites (continued)

PEAK FLOW, CFS

SITE NO.[5]	SITE DESCRIPTION	25-YEAR 6-HR	25-YEAR 24-HR	25-YEAR 72-HR[6]	100-YEAR 6-HR	100-YEAR 24-HR	100-YEAR 72-HR[6]	500-YEAR 6-HR	500-YEAR 24-HR	500-YEAR 72-HR[6]	PMP 1-HR	PMP 6-HR	PMP 24-HR	PMP 72-HR[6]
26	runoff to Woman Cr. Diversion Dam	270	1,600	1,600	1,500	2,500	2,500	2,400	2,900	2,900	5,800	13,000	16,000	16,000
27	runoff through Woman Cr. Diversion Dam	270	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	amount spilled to Pond C-2 from Woman Cr. Diversion Dam	0	400	400	310	1,300	1,300	1,200	1,700	1,700	4,500	11,000	15,000	15,000
28	runoff to Pond C-2	100	450	450	360	1,300	1,300	1,200	1,700	1,700	4,600	12,000	16,000	16,000
29	outflow - Pond C-2[1]	0	0	0	0	1,300	1,300	1,200	1,700	1,700	--	--	--	--
	[2]	0	250	250	130	1,300	1,300	1,200	1,700	1,700	--	--	--	--
	[3]	110	420	420	340	1,300	1,300	1,200	1,700	1,700	4,600	12,000	16,000	16,000
30	Woman Creek at Indiana St. [1]	350	1,400	1,400	1,400	2,700	2,700	2,500	3,200	3,200	--	--	--	--
	[2]	350	1,500	1,500	1,400	2,700	2,700	2,600	3,200	3,200	--	--	--	--
	[3]	410	1,700	1,700	1,700	2,700	2,700	2,600	3,200	3,200	7,800	15,000	21,000	21,000
31	Standley Lake Trib. at Indiana St.	62	140	140	130	230	230	200	330	330	1,600	2,000	2,800	2,800

NOTES:

[1] - Ponds A-4, B-5 and C-2 empty at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

[2] - Ponds A-4, B-5 and C-2 half full at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

[3] - Ponds A-4, B-5 and C-2 full at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

[4] - Ponds A-4, B-5 and Great Western Reservoir full at beginning of storm event.

[5] - See Appendix D for discussion of values presented for 72-hour events.

[6] - Site numbers refer to locations shown on Figure 4.

Flows in the Upper Church and McKay Ditches are conveyed across the South Boulder Diversion Canal in flumes consisting of half-cylindrical metal pipes, the carrying capacities of which were estimated to be 94 cfs and 170 cfs, respectively (Appendix C, Table C-1). Flow in excess of these amounts would spill into the South Boulder Diversion Canal and be conveyed out of the North Walnut Creek watershed. Flow in the Kinnear Ditch is routed under the South Boulder Diversion Canal through a large, rectangular, concrete culvert judged sufficient to pass the ditch's carrying capacity.

The Coal Creek flood-flow simulations, done using the SCS model TR-20, were set up such that the first 600 cfs was retained in Coal Creek. Flow in excess of 600 cfs up to an additional 94 cfs was routed to Upper Church Ditch. Then, flow in excess of that retained in Coal Creek plus that routed into Upper Church Ditch (600 cfs + 94 cfs = 694 cfs), up to an additional 170 cfs was routed to McKay Ditch. Additional runoff, in excess of 864 cfs (600 cfs + 94 cfs + 170 cfs = 894 cfs), up to an additional 1,600 cfs was then routed to Kinnear Ditch. Runoff exceeding 600 cfs plus the combined capacities of the ditches (a total of 2,464 cfs) was retained in the Coal Creek basin. Appendix C, Table C-2 presents Coal Creek basin characteristics used to model the watershed with TR-20.

Flood flow contributed to the RFP basins from Coal Creek through irrigation ditches was not considered in the analysis of the 1-hour local PMP. Because, by definition, the local-storm PMP is of limited duration and areal extent, the limits of the storm were assumed to coincide with the drainage divides of the Walnut and Woman Creek watersheds.

3.3 SOUTH BOULDER DIVERSION CANAL FLOOD RUNOFF

In a previous study (McCall-Ellingson, 1978), it was judged that, during an extreme precipitation and runoff event, such as the PMP, the South Boulder Diversion Canal would fail. The South Boulder Diversion Canal carries water diverted from South Boulder Creek in a southerly direction from South Boulder Creek to Ralston Reservoir. It is located west of the RFP, just east of State

Highway 93 (Figure 3). The previous study estimated the canal's maximum capacity to be 3,200 cfs. Because a gate exists in the canal at its downstream end where it crosses the Kinnear Ditch, it was judged that the entire 3,200 cfs would spill into the Woman Creek basin from the South Boulder Diversion Canal. Where the South Boulder Diversion Canal crosses the Upper Church and McKay Ditches (N. Walnut Creek watershed), McCall-Ellingson (1978) estimated that approximately 1,100 cfs would flow into the North Walnut Creek basin if the above-grade berms of the Canal failed. During the current study, those amounts (3,200 cfs to Woman Creek and 1,100 cfs to N. Walnut Creek) were added to the 6-, 24- and 72-hour PMP peak flows determined using TR-20. As with Coal Creek, flood runoff from the South Boulder Diversion Canal was not included as part of the analysis of the 1-hour local-storm PMP.

3.4 WOMAN CREEK WATERSHED

Storm runoff was simulated with the SCS model TR-20 in the Woman Creek watershed using the precipitation distributions discussed in Section 2.0 of this report for recurrence intervals of 25 years, 100 years, 500 years and the PMP. For each storm frequency and the general-storm PMP, storm durations of 6 hours, 24 hours and 72 hours were simulated. For the local-storm PMP, the 1-hour duration event was simulated. Three scenarios regarding Pond C-2 were considered during analysis of the 25-, 100- and 500-year event. The first simulation assumed the pond to be empty, the second simulation assumed it to be one-half full, and the third simulation assumed it to be full at the time the storm event occurred. The elevation-pond capacity relationship used during this study was that presented in the as-built specifications (McCall-Ellingson, 1978). All three scenarios assumed a worst-case condition that Pond C-1 would be full at the time of occurrence of the storm event. The contribution of storm runoff from Coal Creek through Kinnear Ditch, also estimated with TR-20 (Section 3.2), was added to peak flows and volumes arising from the Woman Creek watershed. For PMP events, Pond C-2 was assumed to be full at the beginning of the storm. Additionally, as discussed previously, a peak flow of

3,200 cfs from the South Boulder Diversion Canal was included for the 6-, 24- and 72-hour duration PMP events (Section 3.3). Table 5 summarizes peak flows and Table 6 summarizes runoff volumes estimated for the Woman Creek watershed at several key locations (Figure 4).

It should be noted that the peak-flow values on Table 5 for the 72-hour duration event are the same as those given for the 24-hour duration event. TR-20 model results did not indicate that the values were the same, although, based on precipitation distributions used, the 24-hour and 72-hour peak-flow values should be the same. However, because of computational limitations discovered in the TR-20 model, the 72-hour values were less than the 24-hour values, and differed by approximately 10 percent. See Appendix D, Model Limitations, for a more detailed discussion.

Sequentially, the simulation of the Woman Creek watershed proceeded as follows. For all simulations except the 1-hour local-storm PMP, Coal Creek was first simulated. If the flood flow in Coal Creek was sufficient, spillage into the Kinnear Ditch, to a maximum of 1,600 cfs, was routed to the point where the Kinnear Ditch crosses under the South Boulder Diversion Canal. At that point runoff from the Woman Creek basin upstream (west) from Highway 93 (subbasin 11, Figure 4) was added to the Kinnear Ditch flow. For the 6-, 24- and 72-hour PMP events, South Boulder Diversion Canal input of 3,200 cfs was also added. The combined hydrograph then was routed to the Woman Creek Diversion Dam. Runoff from the Woman Creek subbasin upstream from the Woman Creek Diversion Dam (subbasin 10, Figure 4) was added to the routed hydrograph. Then the South Interceptor Ditch subbasins (subbasins 9a through 9d, Figure 4) were analyzed. Runoff from the first reach of the South Interceptor Ditch subbasin was estimated. If its amount exceeded the reach's conveyance capacity, the excess was routed to the Woman Creek Diversion Dam and combined with the hydrograph previously described for that location. The amount retained in the first reach of the ditch was routed through the second reach (subbasin 9b) and combined with the runoff arising from that subbasin. This combined hydrograph was then compared with the ditch's conveyance capacity, and the excess routed to and combined with the hydrograph at the Woman Creek Diversion Dam. Similarly, reaches 3

Table 6
Estimated Runoff Volumes at Selected RFP Surface-Water Sites

RUNOFF VOLUME, AC-FT

SITE NO.[5]	SITE DESCRIPTION	25-YEAR 6-HR	25-YEAR 24-HR	25-YEAR 72-HR[6]	100-YEAR 6-HR	100-YEAR 24-HR	100-YEAR 72-HR[6]	500-YEAR 6-HR	500-YEAR 24-HR	500-YEAR 72-HR[6]	PMP 1-HR	PMP 6-HR	PMP 24-HR	PMP 72-HR[6]
1	Coal Cr. @ USGS gage	270	610	1,000	540	1,100	1,700	960	1,800	2,700	--	17,000	26,000	32,000
2	Upper Church + McKay Ditches @ S. Boulder Diversion Canal	14	63	67	88	110	110	130	160	170	--	590	2,500	7,700
3	runoff to N. Walnut Creek Diversion Dam	44	110	140	130	180	210	200	270	320	270	1,200	3,400	8,900
	runoff to McKay Byp., Reach 1, from N.Walnut Cr. Diversion Dam	44	100	130	120	160	190	170	220	270	97	230	670	1,900
	amount spilled to N. Walnut Cr. from N. Walnut Cr. Div. Dam	0	9	9	11	28	28	27	51	51	170	1,000	2,800	6,900
4	McKay Byp., Reach 1	45	110	140	120	160	200	180	230	280	110	270	720	2,000
	amount spilled to Landfill S.Interceptor from McKay Bypass	0	0	0	0	0	0	0	0	0	0	0	3	3
5	McKay Byp., Reach 2	49	110	150	130	170	210	190	240	300	150	360	860	2,200
	amount spilled to Landfill N. Interceptor from McKay Bypass	0	0	0	0	0	0	0	0	0	9	21	44	44
6	McKay Byp., Reach 3	56	120	160	140	190	240	200	270	340	210	500	1,000	2,400
	amount spilled from McKay Bypass to Landfill Reservoir Basin	0	0	0	0	0	0	0	0	0	36	71	120	120
7	McKay Bypass, Reach 4	64	140	180	160	210	270	220	300	380	260	640	1,200	2,700
8	Landfill S. Interceptor	2	3	4	3	4	6	4	6	9	15	36	56	67
	amount spilled from Landfill S. Interceptor to Landfill Reservoir	0	0	0	0	0	0	0	0	0	0	0	2	2

Table 6 (con't.)
Estimated Runoff Volumes at Selected RFP Surface-Water Sites

RUNOFF VOLUME, AC-FT

SITE NO.[5]	SITE DESCRIPTION	25-YEAR 6-HR	25-YEAR 24-HR	25-YEAR 72-HR[6]	100-YEAR 6-HR	100-YEAR 24-HR	100-YEAR 72-HR[6]	500-YEAR 6-HR	500-YEAR 24-HR	500-YEAR 72-HR[6]	PMP 1-HR	PMP 6-HR	PMP 24-HR	PMP 72-HR[6]
9	Landfill N. Interceptor	2	3	4	3	4	6	4	6	9	24	57	98	110
	amount spilled from Landfill N. Interceptor to Landfill Reservoir	0	0	0	0	0	0	0	0	0	2	10	34	34
	runoff to Landfill Reservoir	3	5	7	4	7	10	7	10	14	27	71	130	140
10	outflow from Landfill Reservoir	0	<1	3	<1	3	6	2	6	10	22	66	120	130
11	outflow from Landfill Reservoir Basin	25	43	64	39	68	93	60	98	140	290	310	340	1,200
12	runoff to Pond A-4	42	77	100	73	130	160	120	190	230	480	1,700	3,800	8,300
13	outflow - Pond A-4[1]	0	0	8	0	33	62	23	94	140	--	--	--	--
	[2]	0	30	57	27	82	110	72	140	190	--	--	--	--
	[3]	42	77	100	73	130	160	120	190	230	480	1,700	3,800	8,300
14	runoff to Pond B-5	46	70	95	65	100	130	91	130	170	270	620	920	1,100
15	outflow - Pond B-5[1]	0	0	17	0	22	50	13	55	96	--	--	--	--
	[2]	6	30	55	25	60	88	51	93	130	--	--	--	--
	[3]	46	70	95	65	100	130	91	130	170	270	620	920	1,100
16	confluence of N. & [1]	29	50	98	45	130	220	110	260	390	--	--	--	--
	S. Walnut Cr. & [2]	36	110	190	97	220	310	190	350	480	--	--	--	--
	Landfill Res. Basin[3]	120	200	270	180	310	390	280	440	560	1,100	3,100	5,900	11,000
17	Walnut Cr. @ Indiana[1]	130	250	380	260	450	620	420	700	970	--	--	--	--
	[2]	140	310	460	310	530	710	500	790	1,100	--	--	--	--
	[3]	220	400	550	400	620	790	590	880	1,100	1,700	4,600	8,400	15,000
18	Great Western Res. Trib. @ Indiana	20	34	49	31	52	70	46	73	100	170	420	630	780
19	runoff to Great [1]	240	430	630	420	720	980	660	1,100	1,500	--	--	--	--
	Western Reservoir[2]	240	490	720	470	800	1,100	750	1,200	1,600	--	--	--	--
	[3]	330	580	810	560	890	1,200	830	1,300	1,700	2,600	6,800	12,000	19,000

Table 6 (con't.)
Estimated Runoff Volumes at Selected RFP Surface-Water Sites

RUNOFF VOLUME, AC-FT

SITE NO.[5]	SITE DESCRIPTION	25-YEAR			100-YEAR			500-YEAR			PMP			
		6-HR	24-HR	72-HR[4]	6-HR	24-HR	72-HR[4]	6-HR	24-HR	72-HR[4]	1-HR	6-HR	24-HR	72-HR[4]
20	outflow from Great[1]	0	0	0	0	0	34	0	31	380	--	--	--	--
	Western Reservoir[2]	0	0	0	0	0	89	0	51	450	--	--	--	--
	[3]	0	0	0	0	1	160	0	72	520	950	5,000	9,800	17,000
	[4]	330	580	800	560	890	1,200	830	1,300	1,700	2,500	6,800	12,000	19,000
	Coal Cr. flow to Kinnear Ditch	0	130	130	120	330	350	400	470	500	--	1,000	2,700	5,700
21	Woman Cr. & Kinnear Ditch @ S. Boulder Diversion Canal	27	170	180	170	400	450	470	580	660	290	7,300	9,600	25,000
22	S. Interceptor Ditch, Reach 1	3	5	7	4	7	10	7	10	14	25	60	90	110
	amount spilled to Woman Cr. from S. Interceptor, Reach 1	0	0	0	0	0	0	0	<1	0	16	22	33	33
23	S. Interceptor Ditch, Reach 2	5	9	13	8	13	18	12	19	26	29	86	130	170
	amount spilled to Woman Cr. from S. Interceptor, Reach 2	0	0	0	0	0	0	0	0	0	9	13	21	21
24	S. Interceptor, Reach 3	7	12	17	11	18	24	16	25	34	35	110	160	220
	amount spilled to Woman Cr. from S. Interceptor, Reach 3	0	0	0	0	0	0	0	0	0	7	9	15	15
25	S. Interceptor, Reach 4	18	31	45	28	48	64	42	67	91	130	390	570	730
	amount spilled to Woman Cr. from S. Interceptor, Reach 4	0	0	0	0	0	0	0	0	0	57	110	170	170

Table 6 (con't.)
Estimated Runoff Volumes at Selected RFP Surface-Water Sites

RUNOFF VOLUME, AC-FT

SITE NO.[5]	SITE DESCRIPTION	25-YEAR 6-HR	25-YEAR 24-HR	25-YEAR 72-HR[6]	100-YEAR 6-HR	100-YEAR 24-HR	100-YEAR 72-HR[6]	500-YEAR 6-HR	500-YEAR 24-HR	500-YEAR 72-HR[6]	PMP 1-HR	PMP 6-HR	PMP 24-HR	PMP 72-HR[6]
26	runoff to Woman Cr. Diversion Dam	87	280	350	260	580	700	630	840	1,000	1,100	4,700	12,000	28,000
27	runoff through Woman Cr. Diversion Dam	87	260	330	250	400	520	470	540	700	410	830	2,400	7,000
	amount spilled to Pond C-2 from Woman Cr. Diversion Dam	0	21	21	16	170	180	150	300	310	640	3,900	9,900	21,000
28	runoff to Pond C-2	18	52	52	45	220	240	200	370	410	710	4,200	10,000	22,000
29	outflow - Pond C-2[1]	0	0	0	0	150	170	120	300	330	--	--	--	--
	[2]	0	20	21	12	190	210	170	340	380	--	--	--	--
	[3]	18	52	52	45	220	240	200	370	420	710	4,200	10,000	22,000
30	Woman Cr. @ Indiana[1]	120	320	430	300	650	820	680	970	1,200	--	--	--	--
	[2]	120	340	450	320	690	860	720	1,000	1,300	--	--	--	--
	[3]	140	370	490	350	730	900	760	1,100	1,300	1,500	5,900	14,000	31,000
31	Standley Lake Trib. at Indiana St.	13	22	33	20	35	48	31	51	70	130	310	470	580

NOTES:

1 - Ponds A-4, B-5 and C-2 empty at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

2 - Ponds A-4, B-5 and C-2 half full at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

3 - Ponds A-4, B-5 and C-2 full at beginning of storm event, and Great Western Reservoir at typical pool (5,600 ft above MSL).

4 - Ponds A-4, B-5 and Great Western Reservoir full at beginning of storm event.

5 - See Appendix D for discussion of values presented for 72-hour events.

6 - Site numbers refer to locations shown on Figure 4.

and 4 of the South Interceptor Ditch were analyzed. The amount retained in the Ditch at its downstream end was routed to Pond C-2. The combined hydrograph at the Woman Creek Diversion Dam was routed through the culverts there, and any excess flow was directed over the diversion dam and into Pond C-2. In that analysis, the storage capacity behind the diversion dam was considered, and the maximum hydraulic capacity of the culverts, 1,200 cfs, was estimated assuming inlet control (Highway Task Force, 1971). Data are not available to determine whether backwater conditions would occur at the culverts' downstream end. If backwater conditions would occur at the culverts' downstream end during a runoff event, the maximum conveyance capacity of the culverts may be less than the amount estimated assuming inlet control (1,200 cfs). Appendix C, Table C-1 lists hydraulic characteristics of RFP ditches obtained from as-built specifications (McCall-Ellingson, 1978), and Appendix C, Table C-3 gives storage and conveyance characteristics for the Woman Creek Diversion Dam.

Runoff spilled from Pond C-2, if any, was combined with runoff transported through the Woman Creek Diversion Dam into the Woman Creek Bypass Ditch, and the combined hydrograph was routed to Indiana Street. This routed hydrograph was combined with the runoff hydrograph for the Woman Creek subbasin 8 (Figure 4) to yield the final hydrograph in the Woman Creek watershed at Indiana Street.

For the 1-hour local storm PMP, the only differences from the above-described simulation sequence were that no flow was input from Coal Creek through Kinnear Ditch, and no flow was input from the South Boulder Diversion Canal because of the localized nature of this storm.

Figures 5 through 17 present runoff hydrographs at selected sites in the Woman Creek watershed. These hydrographs were developed from results of TR-20 simulations. Figures 18 through 20 present plots of volume of runoff spilled from Pond C-2 versus storm duration for various recurrence interval and PMP storms. Several estimated hydrographs depicted on the previously referenced figures show more than one peak (Figures 8 and 11). This is not unexpected, especially at Pond C-2 and other downstream locations, because these locations would receive flow from more than one source or tributary during storm and runoff events. For example, the South Interceptor Ditch would route storm runoff to Pond C-2. If the storage and conveyance capacity of the Woman Creek Diversion Dam were to be exceeded during a storm event, the excess would also flow into Pond C-2. The peak discharges to Pond C-2 from the South Interceptor Ditch and the Woman Creek Diversion Dam might reasonably be expected to occur at different times, and, indeed, this is what was predicted to occur (Figure 8).

Table 7 is a summary of storms during which the capacities of RFP surface-water conveyance and storage structures would be exceeded.

TABLE 7

STORMS DURING WHICH THE CAPACITY OF RFP SURFACE-WATER CONVEYANCE AND STORAGE STRUCTURES WOULD BE EXCEEDED

STRUCTURE	STORM RECURRENCE INTERVAL												
	25-YEAR			100-YEAR			500-YEAR			PMP			
	DURATION			DURATION			DURATION			DURATION			
	6-hr	24-hr	72-hr	6-hr	24-hr	72-hr	6-hr	24-hr	72-hr	1-hr	6-hr	24-hr	72-hr
N. Walnut Cr. Diversion Dam		●	●	●	●	●	●	●	●	●	●	●	●
McKay Bypass - Reach 1												●	●
McKay Bypass - Reach 2										●	●	●	●
McKay Bypass - Reach 3										●	●	●	●
McKay Bypass - Reach 4													
Landfill S. Interceptor Ditch												●	●
Landfill N. Interceptor Ditch										●	●	●	●
Woman Cr. Diversion Dam		●	●	●	●	●	●	●	●	●	●	●	●
South Interceptor - Reach 1								●	●	●	●	●	●
South Interceptor - Reach 2										●	●	●	●
South Interceptor - Reach 3										●	●	●	●
South Interceptor - Reach 4										●	●	●	●
Pond A-4 - empty			●		●	●	●	●	●	●	●	●	●
Pond B-5 - empty			●		●	●	●	●	●	●	●	●	●
Pond C-2 - empty					●	●	●	●	●	●	●	●	●
Pond A-4 - half full		●	●	●	●	●	●	●	●	●	●	●	●
Pond B-5 - half full	●	●	●	●	●	●	●	●	●	●	●	●	●
Pond C-2 - half full		●	●	●	●	●	●	●	●	●	●	●	●
Great Western Res. spillway										●	●	●	●

3.5 WALNUT CREEK WATERSHED

Similar to that procedure described previously for the Woman Creek watershed, the Walnut Creek watershed was modeled using the SCS program TR-20 for the storm frequencies and durations of interest. Coal Creek inflow through Upper Church and McKay ditches was added according to TR-20 simulations of Coal Creek (Section 3.2), and 1,100 cfs was added for the 6-, 24- and 72-hour PMP events from South Boulder Diversion Canal (Section 3.3). Tables 5 and 6 present estimates of flood-peak flows and runoff volumes, respectively, for several locations in the Walnut Creek watershed (Figure 4). For the 25-, 100- and 500-year storms, three TR-20 simulations were made assuming that Ponds A-4 and B-5 were empty, one-half full and full, respectively, at the time of occurrence of the storm events. Elevation-pond capacity curves for Ponds A-4 and B-5 were obtained from the as-built specifications (McCall-Ellingson, 1978). Ponds A-1 through A-3 and B-1 through B-4 were assumed to be full at the time of occurrence of the storm events. For analysis of the PMP storms, Ponds A-4 and B-5 were assumed to be full.

The sequence of TR-20 simulation of the Walnut Creek watershed proceeded as follows. Coal Creek's watershed response was first simulated. If the runoff amount in Coal Creek was greater than 600 cfs, excess flow was diverted into the Upper Church and McKay Ditches, to a maximum of 94 cfs in the Upper Church Ditch and 170 cfs in the McKay Ditch. These amounts were routed to the headwaters of the North Walnut Creek watershed at the South Boulder Diversion Canal. At that point, for simulations of 6-, 24- and 72-hour general-storm PMP's, 1,100 cfs were added as the estimated contribution from the South Boulder Diversion Canal. The combined hydrograph then was routed to the North Walnut Creek Diversion Dam and combined with the runoff arising from subbasin 7 (Figure 4). The storage capacity behind the North Walnut Creek Diversion Dam was determined from 2-ft contour interval maps (Appendix C, Table C-3). The conveyance capacity of the culverts from the North Walnut Creek Diversion Dam to the McKay Bypass Ditch (330 cfs) was estimated using information obtained from as-built specifications (McCall-Ellingson, 1978) and techniques detailed in Highway Task Force

(1971). The capacity of the West Interceptor Ditch was not specifically simulated. It was judged that the storage and conveyance capabilities of the North Walnut Creek Diversion Dam are limiting in that area. If the West Interceptor Ditch's capacity is exceeded, the excess would flow into the North Walnut Creek subbasin containing Ponds A-1 through A-4. Similarly, if the storage and conveyance capacities of the North Walnut Creek Diversion Dam are exceeded, the excess runoff would flow into the same watershed.

As stated previously, runoff in excess of the storage capacity behind the North Walnut Creek Diversion Dam and the hydraulic capacity of the culverts was diverted into the North Walnut Creek subbasin containing Pond A-4 (subbasin 5). Flow diverted to the McKay Bypass Ditch, reach 1 (subbasin 2a), was routed to the subbasin's outlet and combined with the subbasin's runoff. Any amount in excess of the McKay Bypass Ditch, reach 1, capacity was directed to the Landfill South Interceptor Ditch subbasin (3a on Figure 4). Flow retained in the McKay Bypass Ditch was routed through the second reach and combined with runoff arising from subbasin 2b. Runoff in excess of McKay Bypass, reach 2, was routed to the Landfill North Interceptor Ditch subbasin 3b. McKay Bypass Ditch flow was then routed through reach 3 and combined with runoff from subbasin 2c. At that point, any runoff exceeding the McKay Bypass Ditch, reach 3, carrying capacity was directed to the Landfill Reservoir subbasin 3d downstream from the Landfill Reservoir. Flow retained in the McKay Bypass Ditch was routed through reach 4 and combined with runoff from subbasin 2d.

If runoff was spilled from the McKay Bypass, reaches 1 and 2, into the Landfill South and North Interceptor Ditches, respectively, that runoff was combined with runoff arising from those subbasins, and the total amounts were compared with the Interceptor Ditches' capacities. Any amount in excess of their carrying capacities was directed to the Landfill Reservoir's subbasin 3c. Excess runoff from the Landfill Interceptor Ditches was combined with runoff in the Landfill Reservoir subbasin and routed through the reservoir. The Landfill Reservoir's beginning elevation was assumed to be 5,919 ft above mean sea level (MSL), which is a typical pool elevation, based on examination of topographic maps and aerial photography. Elevation-capacity and spillway elevation-discharge relationships were obtained from renovation specifications (Zeff, Cogorno & Sealy Inc. and others, 1974). Flow spilled from the Landfill Reservoir was combined with flow carried in the Landfill Interceptor Ditches and routed to the subbasin's outlet, where it was combined with the runoff arising from the area downstream from the Reservoir and any excess spilled from the McKay Bypass Ditch, reach 3.

Runoff in excess of the storage and conveyance capacities of the North Walnut Creek Diversion Dam was routed to Pond A-4, where it was combined with runoff from the Pond A-4 subbasin 5. The combined runoff was then routed through Pond A-4. Runoff from the South Walnut Creek subbasin 5, was routed through Pond B-5 and combined with runoff from the small South Walnut Creek subbasin 4, downstream from Pond B-5. Hydrographs from the North Walnut Creek subbasins containing the Landfill Reservoir and Pond A-4 were combined with the South Walnut Creek watershed hydrograph to yield the hydrograph at the confluence of North Walnut and South Walnut Creeks.

This hydrograph was then routed to Indiana Street, where it was combined with the routed McKay Bypass Ditch runoff and the runoff arising from Walnut Creek subbasin 1. This sequence yielded the runoff hydrograph for Walnut Creek at Indiana Street. The Walnut Creek runoff at Indiana Street was routed to Great Western Reservoir and combined with runoff from subbasins 12, 14 and 15. This combined runoff then was routed through Great Western Reservoir. The routing of flow through Great Western Reservoir was done for two scenarios. First, a typical pool elevation (obtained from topographic maps) of 5,600 ft above MSL was assumed, and the second scenario assumed that the pool was at the spillway crest elevation of 5,607 ft above MSL. The elevation-capacity and elevation-spillway discharge relationships for Great Western Reservoir were obtained from a report produced as a part of the U.S. Army Corps of Engineers' National Dam Safety Program (Hydro-Triad, 1981).

Figures 21 through 59 present runoff hydrographs for selected locations within the Walnut Creek watershed, including Great Western Reservoir. Figures 60 through 65 are plots of runoff volume spilled from Ponds A-4 and B-5 versus storm duration for the 25-, 100- and 500-year storm events. Figure 66 presents storm runoff versus PMP storm duration for Ponds A-4, B-5 and C-2. At some of the more downstream locations, estimated hydrographs developed during this study have more than one peak (Figures 35 and 37). The multiple peaks result because these locations would receive runoff from more than one source or tributary. The difference in timing of peak flow at these locations from the different sources or tributaries caused the resultant hydrographs estimated by the TR-20 modeling effort to have multiple peaks.

4.0 PREVIOUS HYDROLOGIC INVESTIGATIONS

Studies to estimate storm-runoff characteristics have been conducted previously at the RFP. In 1978, McCall-Ellingson & Morrill, Inc. (McCall-Ellingson, 1978) conducted storm-runoff studies at the RFP in order to aid in the design and construction of Ponds A-4, B-5 and C-2 and conveyance channels, including the South and West Interceptor Ditches, the McKay Bypass Ditch, and the Woman Creek Bypass Ditch. The 100-year, 72-hour duration event was the design storm for these structures. They also investigated the 1-hour local-storm and 6- and 72-hour general-storm PMP's. Precipitation values (in inches) used for the McCall-Ellingson analyses are presented below. Comparable storm-event values used during the current study are also presented.

		LOCAL	GENERAL STORM	
	100-yr, 72-hr	1-hr PMP	6-hr PMP	72-hr PMP
McCall-Ellingson	6.16	16.78	22	23.11
Current study (Table 1)	6.3	10.7	24	43

Precipitation values from these two sources compare fairly well except for the 1- and 72-hour PMP values. The 1-hour PMP value used by McCall-Ellingson (1978) is greater than that used in the current study, and the 72-hour value used by McCall-Ellingson is much less. McCall-Ellingson used techniques in the U.S. Bureau of Reclamation's (USBR) "Design of Small Dams" , which was an acceptable standard technique. The current study used recently published isohyetal maps provided in the National Weather Service document, HMR-55A (Hansen and others, 1988) (see Section 2.0 of this report). HMR-55A is currently recommended by USBR (Cudworth, 1989) and the Colorado State Engineer.

Peak-flow and storm-runoff values determined for RFP ponds analyzed by McCall-Ellingson (1978), and comparative values determined during the current study are presented below.

	100-yr, 72-hr		PMP, 1-hr		PMP, 72-hr	
	Discharge (cfs)	Runoff (ac-ft)	Discharge (cfs)	Runoff (ac-ft)	Discharge (cfs)	Runoff (ac-ft)
Pond A-4						
McCall-Ellingson	566	70	6,640	1,219	6,603	1,741
Current Study	550	160	3,900	480	7,600	8,300
Pond B-5						
McCall-Ellingson	569	71	3,191	333	2,892	427
Current Study	620	130	3,200	270	5,100	1,100
Pond C-2						
McCall-Ellingson	391	42	17,020	4,983	19,079	6,853
Current Study	1,300	240	4,600	710	16,000	22,000

In many cases, peak-flow values for the current study compare well with the McCall-Ellingson (1978) study values. However, in general, runoff values do not compare well. The hydrologic analysis resulting in the 100-year, 72-hour peak-flow and storm-runoff values are not reported by McCall-Ellingson. However, the hydrologic analysis is described for the PMP flood events. Assuming that the basin characteristics and analysis techniques reported for the PMP events were the same characteristics and techniques used for the 100-year, 72-hour event, then some of the disparity between McCall-Ellingson's runoff values and those of the current study is explained by the runoff curve numbers (CN) used. McCall-Ellingson (1978) and the current study (Table 3) used impervious-area estimates and CN's as follows:

	Runoff Curve Numbers		Percent Impervious Area	
	McCall-Ellingson	Current Study	McCall-Ellingson	Current Study
Pond A-4 basin	70 and 74	81	10	27
Pond B-5 basin	70 and 81	87	25	52
Pond C-2 basin	70 and 73	77 and 72	5	3

The amount of impervious area has increased significantly at the RFP since 1978 due to increased construction of buildings and paved parking areas and roads. Runoff volume is extremely sensitive to the percent of impervious area.

Another source of difference in values reported by McCall-Ellingson (1978) and the current study involve assumptions concerning contribution of storm runoff from Coal Creek. For the 100-year, 72-hour event, McCall-Ellingson assumed no contribution from Coal Creek. In the current study, it was assumed that Coal Creek would contribute flow to the RFP basins through the Upper Church, McKay and Kinnear Ditches during 25-year and 100-year storm events, as well as the larger-magnitude events (Tables 5 and 6). The Coal Creek contribution estimated for the 100-year, 72-hour event during the current study is a source of considerable difference in the reported values for the Pond C-2 basin and, to a lesser extent, the Pond A-4 basin. For the Pond B-5 basin, because no Coal Creek contribution was estimated during either study, the main difference is in the runoff curve number.

For the 1-hour local-storm PMP, McCall-Ellingson assumed a contribution of 15 percent of Coal Creek's flood flow. The current study assumed no contribution from Coal Creek from that storm, because, by definition, the local-storm PMP is limited in areal extent. Additionally, McCall-Ellingson (1978) used a 1-hour local-storm PMP of 16.78 inches, whereas the current study used a value of 10.7 inches.

For the general-storm PMP, McCall-Ellingson (1978) also assumed a contribution of 15 percent of Coal Creek's flood flow. The current study assumed input from Coal Creek based on carrying capacity of the aforementioned irrigation ditches. The largest source of disparity between the two studies' 72-hour PMP runoff volume values is the difference in total precipitation values, 23 inches compared with 43 inches, respectively.

Lee Wan and Associates (1987) conducted a study to define runoff characteristics for the RFP storm-runoff conveyance structures. That study, which utilized the TR-20 model, was limited in scope in that it analyzed only the 25-year, 1-hour storm event. It is not directly comparable with the current study, because the current study did not analyze the 25-year, 1-hour event. Lee Wan's (1987) study was somewhat conservative in that it used 85 as a minimum curve number. In largely impervious areas, that study used curve numbers in excess of 90, with a maximum of

98. The current study estimated curve numbers based on soil type, vegetation type and land use, including estimates of existing impervious area (Table 3).

5.0 ACKNOWLEDGEMENTS

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A. Shah, DOE/EG&G	A. McLean, ER/NEPA
A.D. Berzins, ER/EMAD	R. Lindberg, ER/EMAD
J. Ciucci, Waste Operations	C. Rose, ER/CWAD (Consultant)

This study is submitted in partial fulfillment of the Zero-Offsite Water-Discharge study being conducted by ASI on behalf of EG&G, Rocky Flats Plant, Inc. EG&G's Project Engineer was R. A. Applehans of EG&G, Facilities Engineering, Plant Civil/Structural Engineering (FE/PCSE).

6.0 REFERENCES

Advanced Sciences, Inc. (ASI), 1990a, Predecisional Draft Zero-Offsite Water-Discharge Study Scope Evaluation: March.

Advanced Sciences, Inc. (ASI), 1990b, Project Management Plan, Storm-Runoff Quantity for Various Design Events Study, Task 06 of the Zero-Offsite Water-Discharge Study: August 24, 8p., 2 Appendices, A and B.

Advanced Sciences, Inc. (ASI), 1990c, Project Management Plan, Bypass Upstream Flows Around Rocky Flats Study, Task 24 of the Zero-Offsite Water-Discharge Study: December.

Advanced Sciences, Inc. (ASI), 1990d, Project Management Plan, Temporary Water Storage Capabilities Study, Task 21 of the Zero-Offsite Water-Discharge Study: December.

Advanced Sciences, Inc. (ASI), 1990e, Water-Yield and Water-Quality Study of Other Sources Tributary to Standley Lake and Great Western Reservoir, Task 16 of the Zero-Offsite Water-Discharge Study: December.

Richard P. Arber Associates, Inc., 1984, Standley Lake Water Quality Program, Technical Memorandum No. 2, Evaluation of Impact of Metals on Standley Lake: Consultant's report prepared for the Cities of Thornton and Westminster, October.

Colorado State Engineer, 1988, Rules and Regulations for Dam Safety and Dam Construction: Dept. of Natural Resources, Division of Water Resources, September, 50 p.

Cudworth, A.G., Jr., 1989, Flood Hydrology Manual: U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

EG&G Rocky Flats, Inc., 1990 (draft final), Surface Water and Sediment Monitoring Plan, Environmental Restoration Program, Rocky Flats Plant: Completion Report by Stoller and Associates, Inc., September 28, 47p., 3 figures, 8 tables, and 1 plate.

Haan, C.T. and Barfield, B.J., 1978, Hydrology and Sedimentology of Surface Mined Lands: Office of Continuing Education and Extension, College of Engineering, University of Kentucky, Lexington, KY.

Hansen, E.M., Fenn, D.D., Schreiner, L.C., Stodt, R.W., and Miller, J.F., 1988, Probable Maximum Precipitation Estimates - United States Between the Continental Divide and the 103rd Meridian: Hydrometeorological Report No. 55A, U.S. Department of Commerce, NOAA, U.S. Department of the Army, COE, and U.S. Department of the Interior, USBR, Silver Springs, MD, June.

Highway Task Force, 1971, Handbook of Steel Drainage & Highway Construction Products: Second Edition, American Iron and Steel Institute, Washington D.C.

Hurr, R.T., 1976, Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado: U.S. Geol. Survey Open-File Report 76-268, March, 68p. and 3 plates.

Hydro-Triad, Ltd., 1981, Phase I Inspection Report, National Dam Safety Program, Great Western Reservoir Dam, Jefferson County, Colorado.

Lee Wan and Associates, 1987, Instruction Manual for Site Drainage Computer Model, Rocky Flats Plant, Golden, Colorado: prepared for EG&G, Rocky Flats Inc., Facilities Engineering and Construction, February.

McCall-Ellingson & Morrill, Inc., 1978, Title I Report for Surface Water Control, Department of Energy, Rocky Flats.

McCall-Ellingson & Morrill, Inc., 1980, Operation and Maintenance Instructions for Rocky Flats Surface Water Control Project.

Miller, J.F., Frederick, R.H., and Tracey, R.J., 1973, NOAA Atlas 2, Precipitation - Frequency Atlas of the Western United States, Volume III - Colorado: U.S. Department of Commerce, National Weather Service, Silver Springs, MD.

Soil Conservation Service (SCS), 1975, TR-55, Urban Hydrology for Small Watersheds: Technical Release No. 55, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Soil Conservation Service (SCS), 1977, Procedures for Determining Peak Flows in Colorado, Includes and Supplements - Technical Release No. 55 "Urban Hydrology for Small Watersheds": U.S. Dept. of Agriculture, Soil Conservation Service, Washington, D.C.

Soil Conservation Service (SCS), 1980, Soil Survey of Golden Area, Jefferson County, Colorado: U.S. Dept. of Agriculture, Soil Conservation Service, Washington, D.C.

Soil Conservation Service (SCS), 1983, TR-20, Project Formulation -Hydrology (1982 Vers.): Technical Release No. 20, U.S. Department of Agriculture, Soil Conservation Service, Revised by Northeast NTC and Hydrology Unit, May 1982, Second Edition, May 1983, Washington, D.C.

Soil Conservation Service (SCS), 1986, TR-55, Urban Hydrology for Small Watersheds: Technical Release No. 55, Second Edition, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., June.

Urban Drainage and Flood Control District, 1969, Urban Storm Drainage Criteria Manual: 2 volumes with updates, Prepared for the Denver Regional Council of Governments by Wright McLaughlin Engineers, Denver.

U.S. Department of Energy (DOE), 1986, Standard for Storm Sewer Design Criteria: Rocky Flats Plant Standard No. SC-109, November.

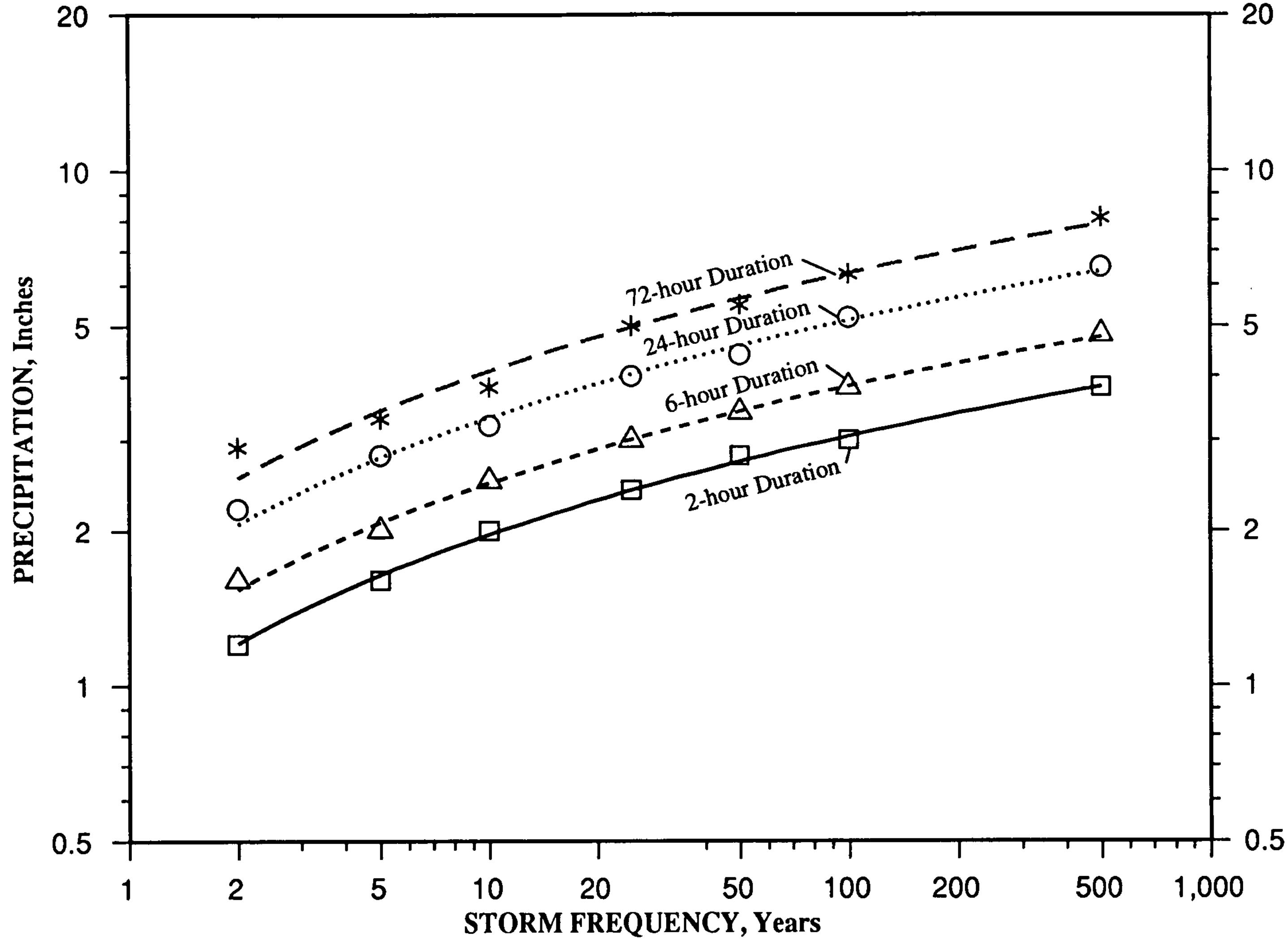
U.S. Department of Energy (DOE), 1989a, Design Criteria Manual: DOE 6430.1A, Two Volumes, April.

U.S. Department of Energy (DOE), 1989b, Compliance With Floodplain/Wetlands Environmental Review Requirements, as directed in 10 CFR 1022 .

Woodward-Clyde Consultants, 1984 (revised), Operations and Maintenance Instructions for Rocky Flats Surface Water Control Project (Dams & Reservoirs), 1980: Original Manual by McCall-Ellingson & Morrill, Inc., Revised by Woodward-Clyde Consultants and Merrick & Co.

Zeff, Cogorno & Sealy Inc., Tri-Consultants Inc., and Hydro-Triad Ltd., 1974, Sanitary Landfill Renovations, Rocky Flats.

FIGURES

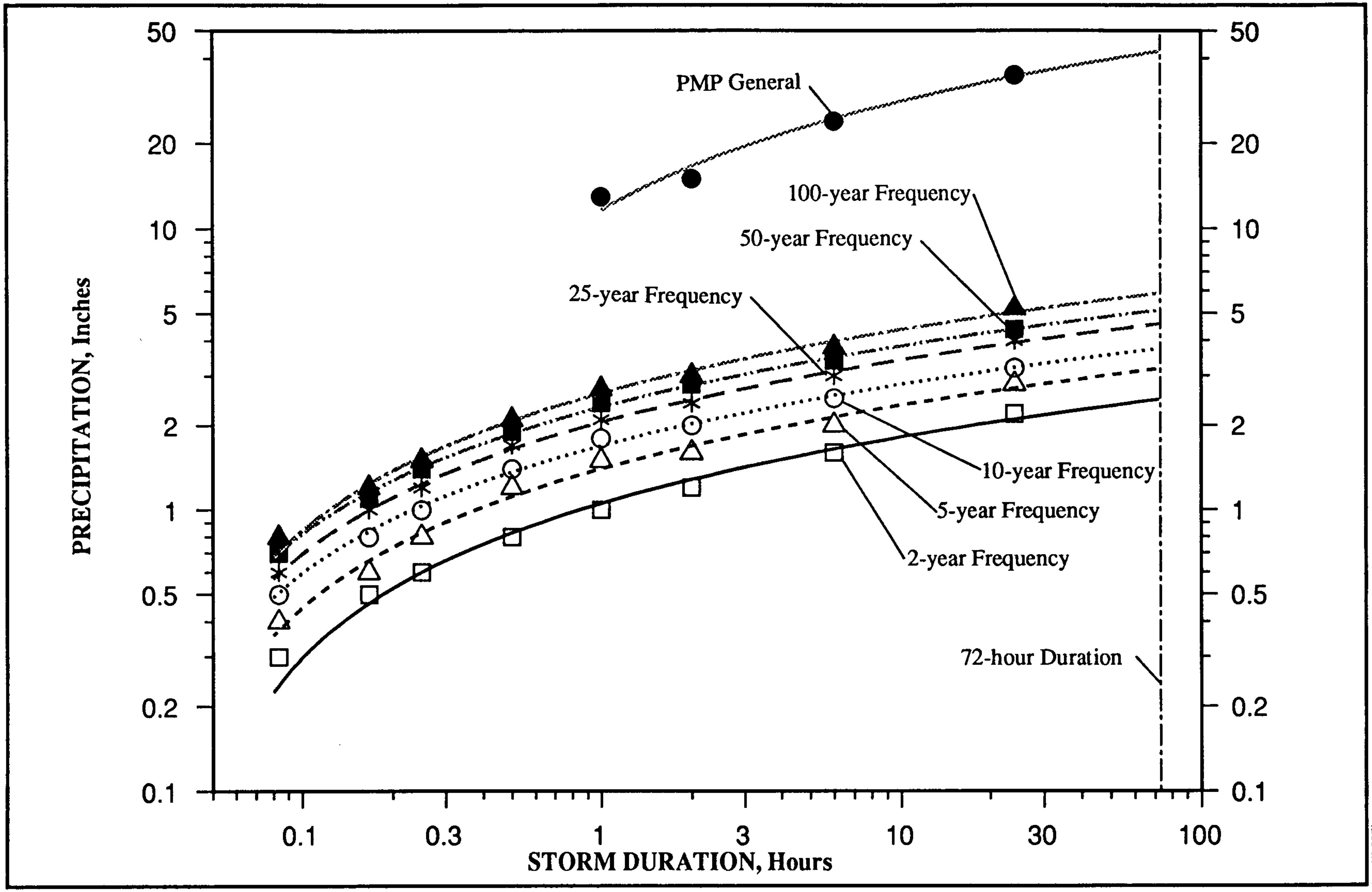


PRECIPITATION VERSUS STORM FREQUENCY

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 1

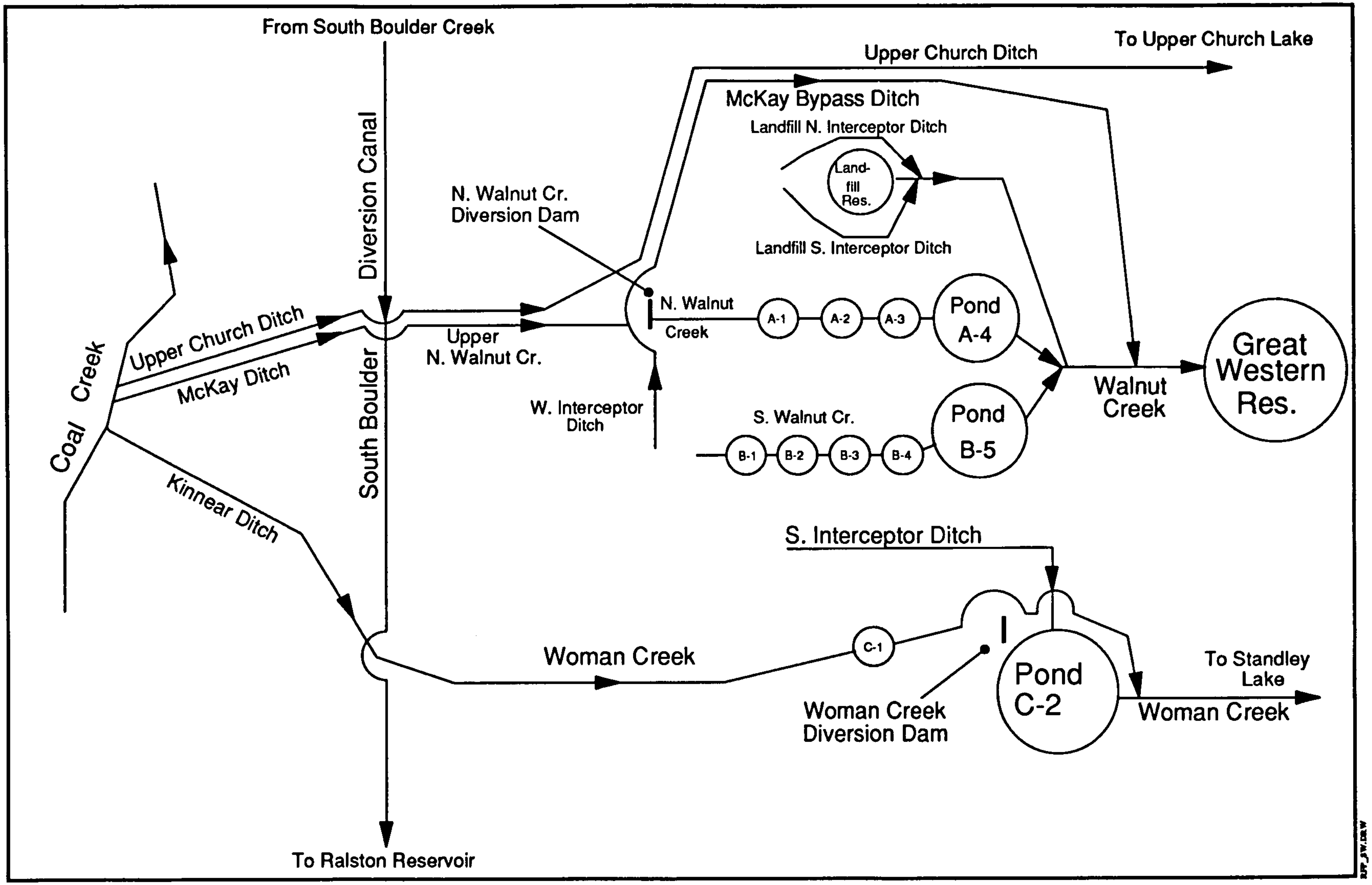


PRECIPITATION VERSUS STORM DURATION

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 2

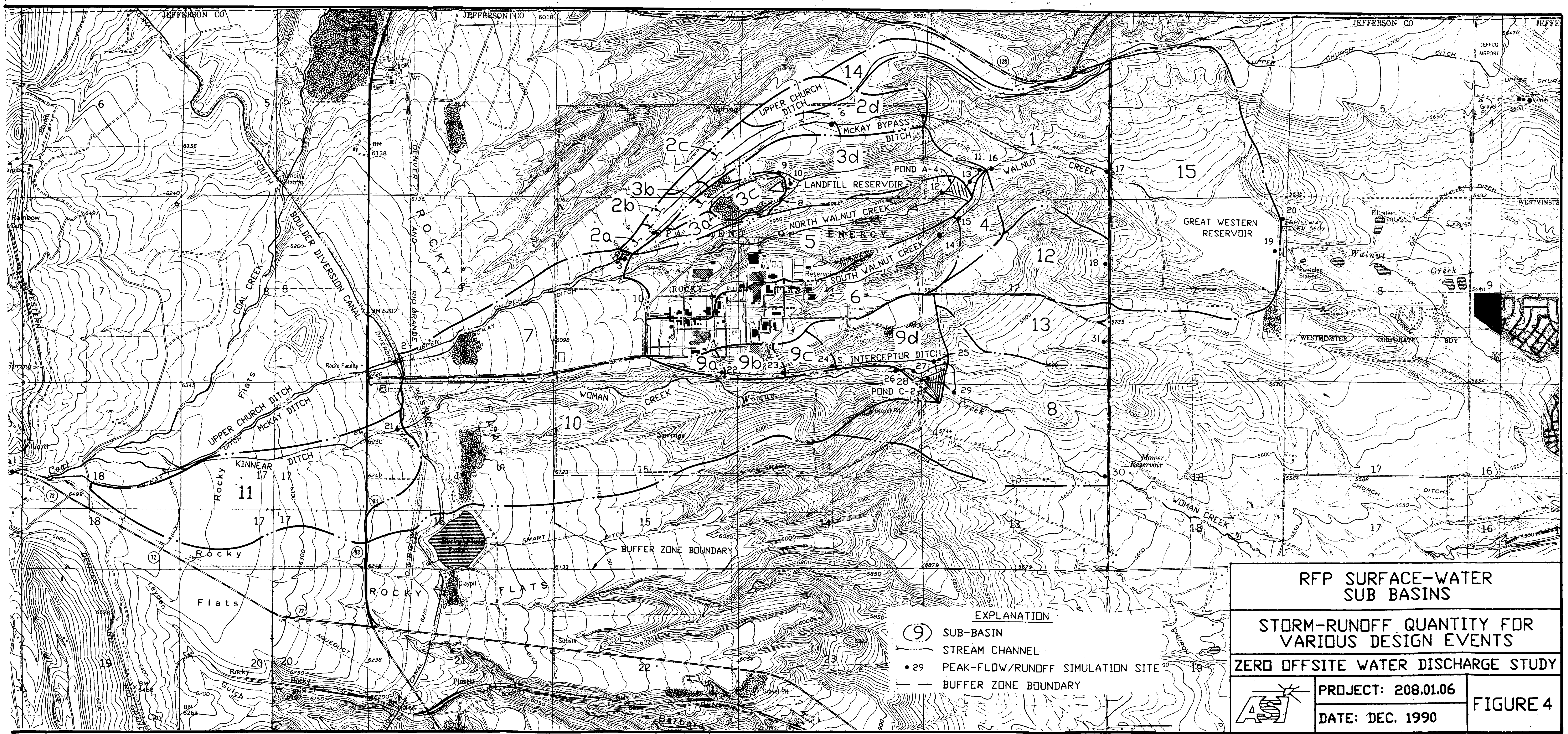


Conceptualized Surface-Water Configuration at the Rocky Flats Plant

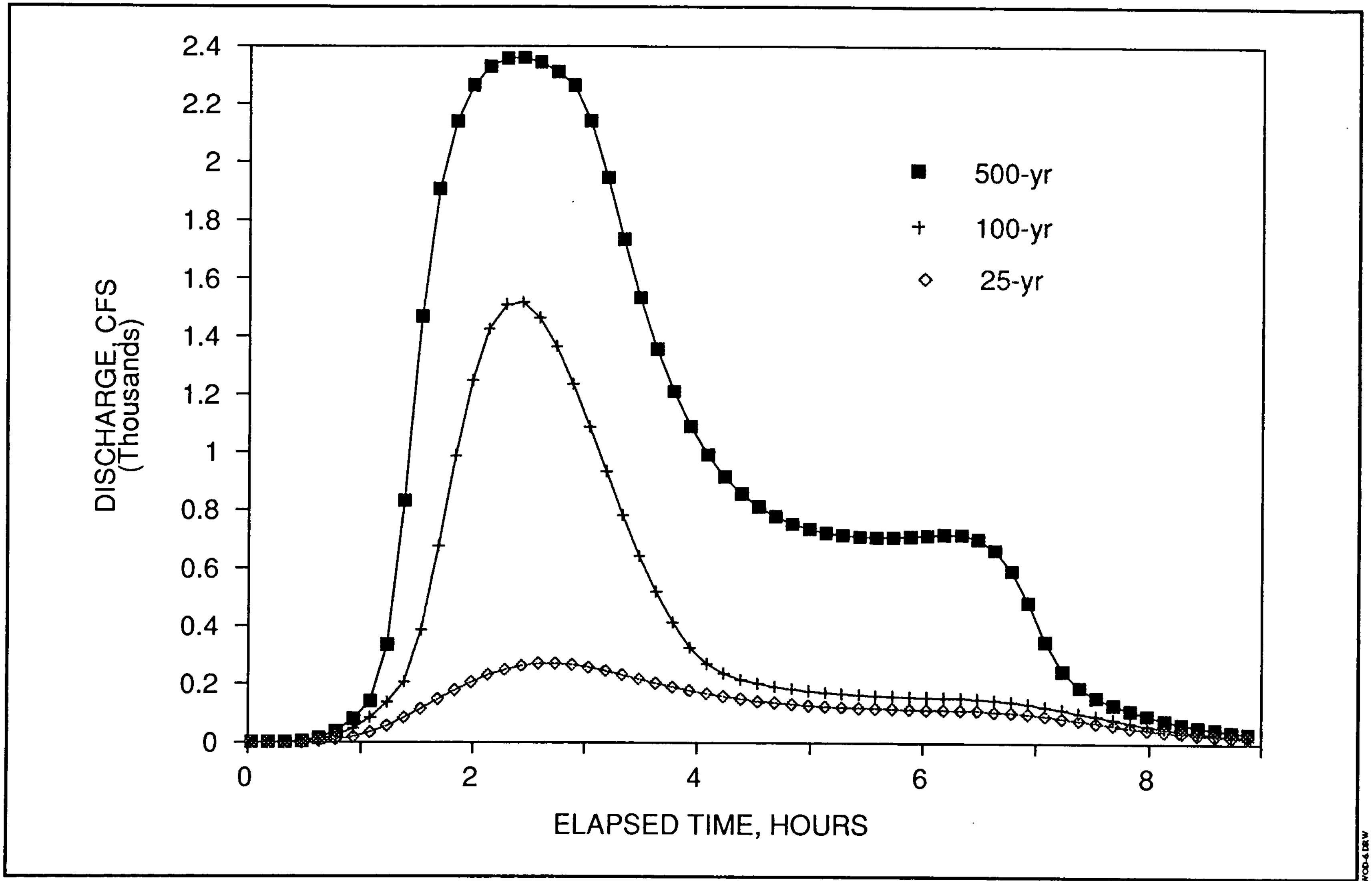
STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 3



RFP SURFACE-WATER SUB BASINS
STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
ZERO OFFSITE WATER DISCHARGE STUDY
PROJECT: 208.01.06
DATE: DEC. 1990
FIGURE 4
EXPLANATION
(9) SUB-BASIN
STREAM CHANNEL
• 29 PEAK-FLOW/RUNOFF SIMULATION SITE
BUFFER ZONE BOUNDARY
JEFFERSON CO
UPPER CHURCH DITCH
MCKAY BYPASS DITCH
POND A-4
LANDFILL RESERVOIR
NORTH WALNUT CREEK
SOUTH WALNUT CREEK
WALNUT CREEK
GREAT WESTERN RESERVOIR
S. INTERCEPTOR DITCH
POND C-2
WOMAN CREEK
SMART DITCH
BUFFER ZONE BOUNDARY
SOUTH BOULDER DIVERSION CANAL
COAL CREEK
MCKAY DITCH
KINNEAR DITCH
ROCKY FLATS
Rocky Flats Lake
WESTMINSTER CORPORATE BDY
CHURCH DITCH

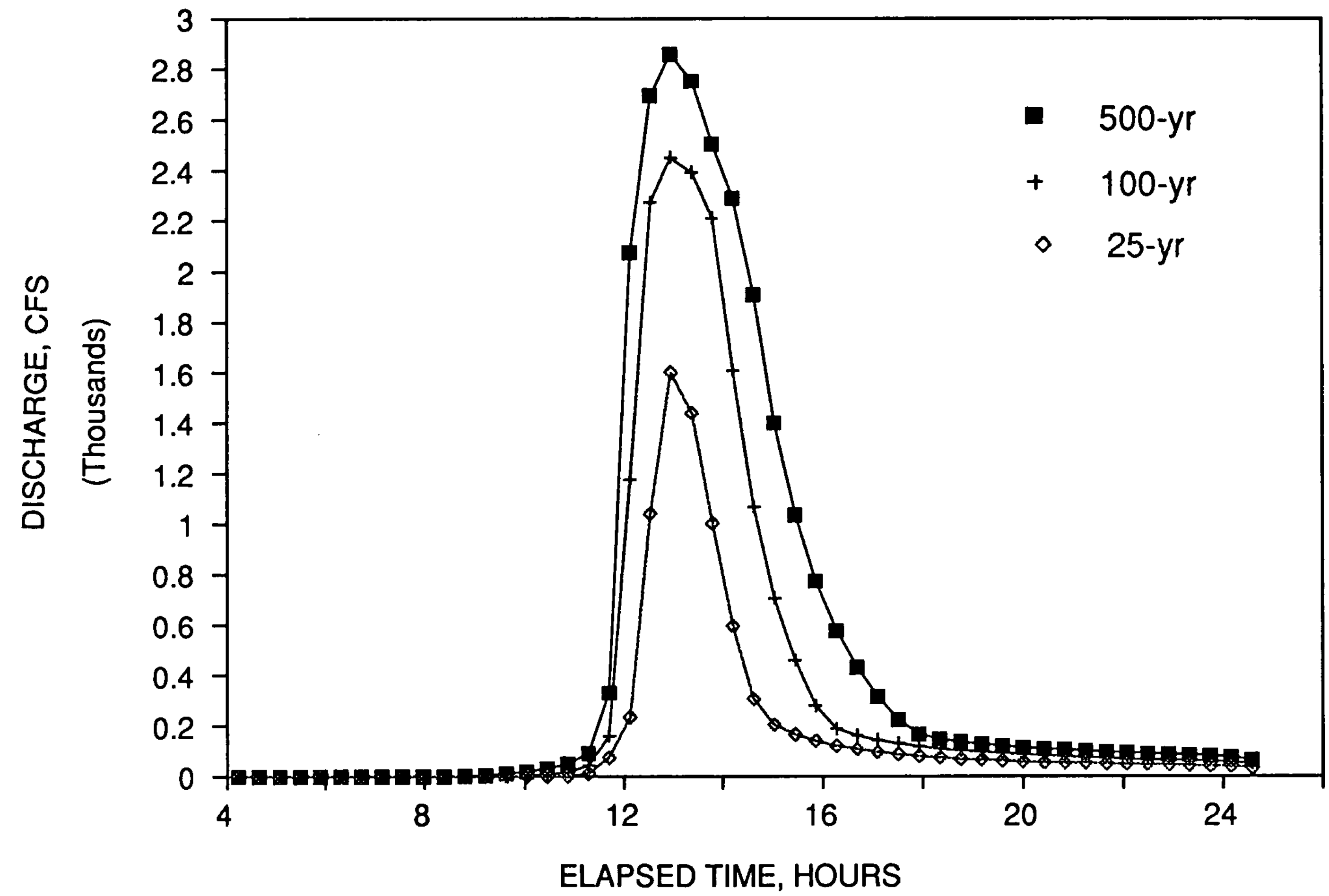


ESTIMATED FLOOD HYDROGRAPHS FOR THE WOMAN CREEK DIVERSION DAM (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 5

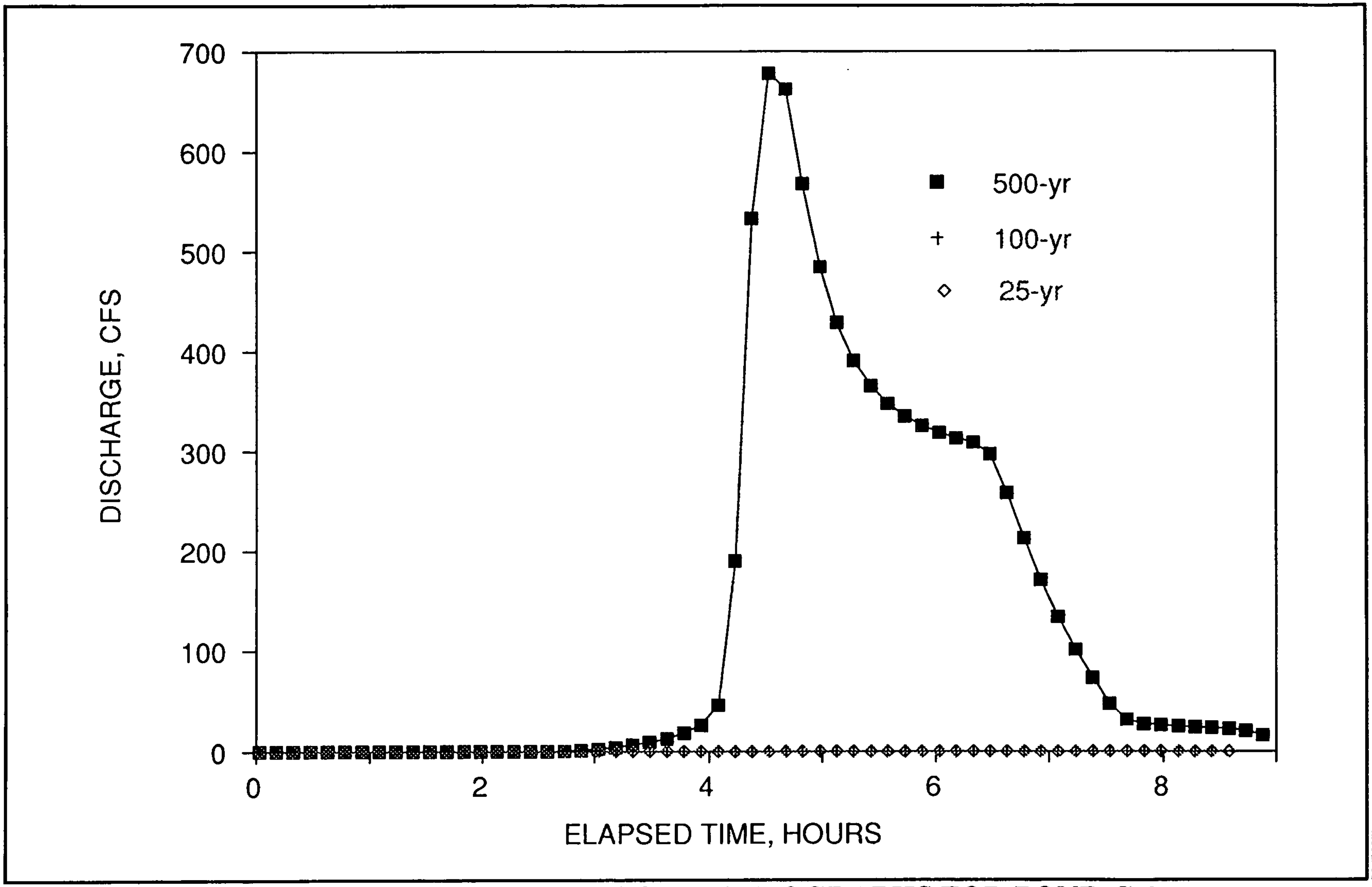


ESTIMATED FLOOD HYDROGRAPHS FOR THE WOMAN CREEK DIVERSION DAM (24-HOUR DURATION)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 6

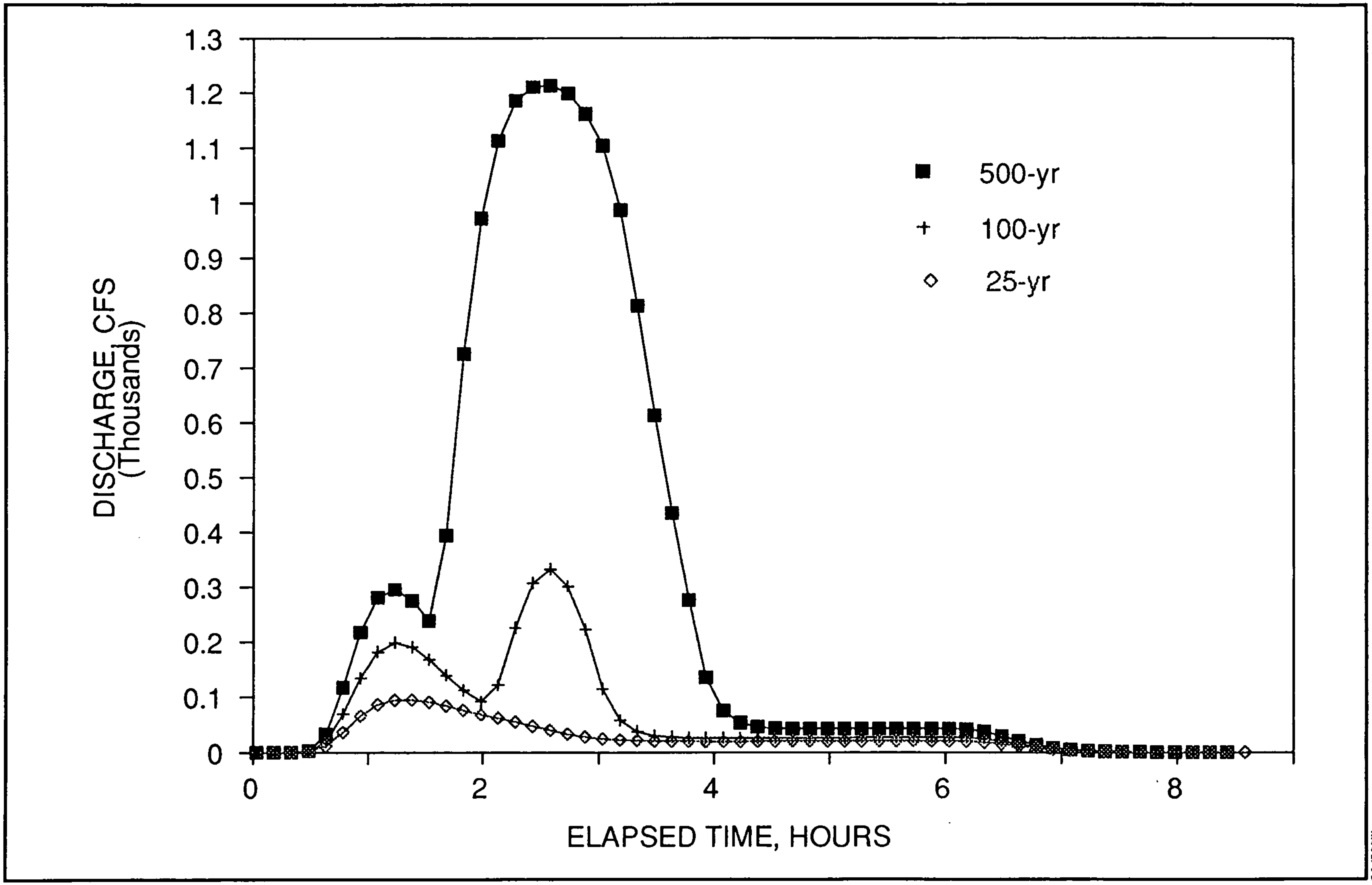


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND C-2
(POND EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 7

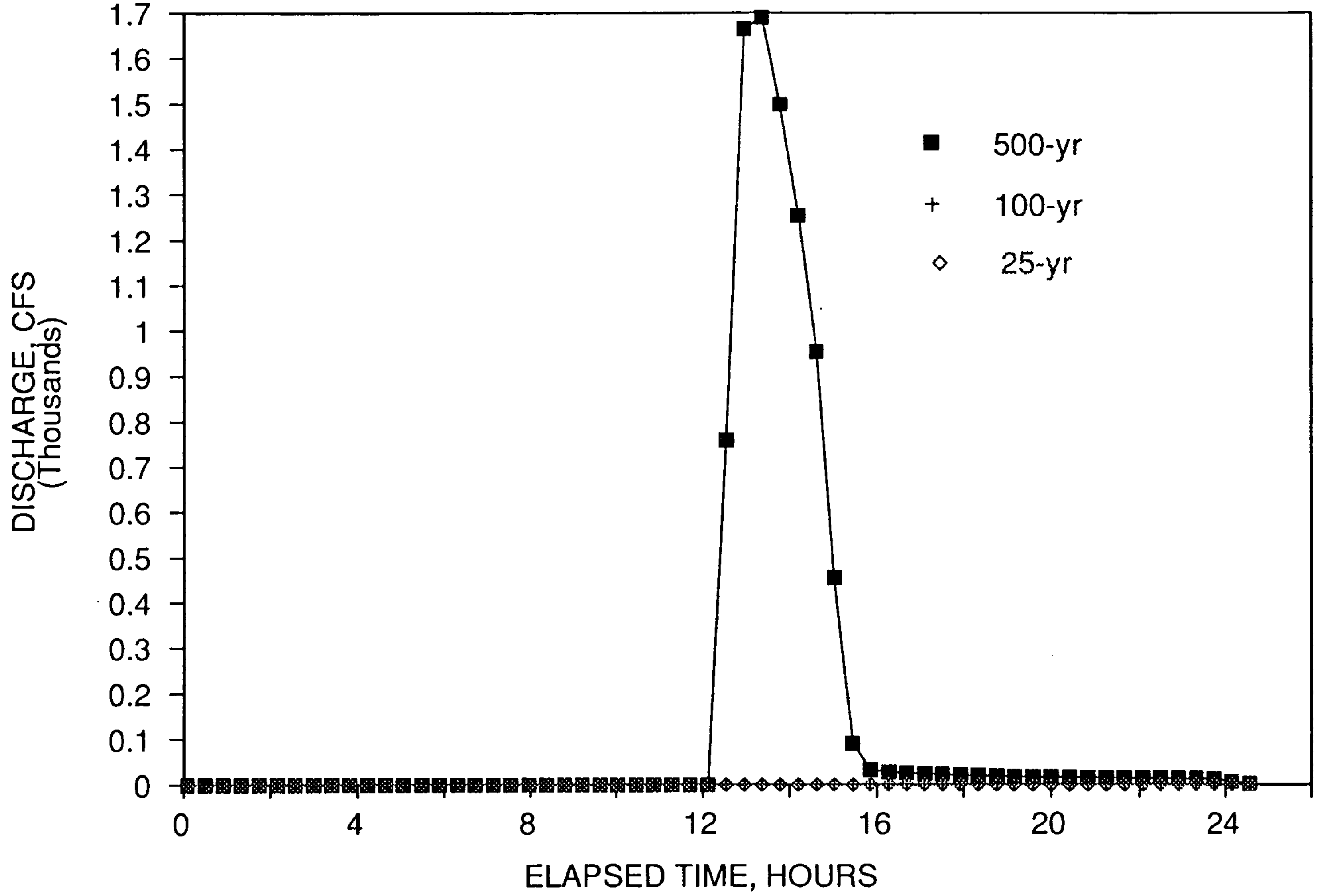


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND C-2
(POND FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 8

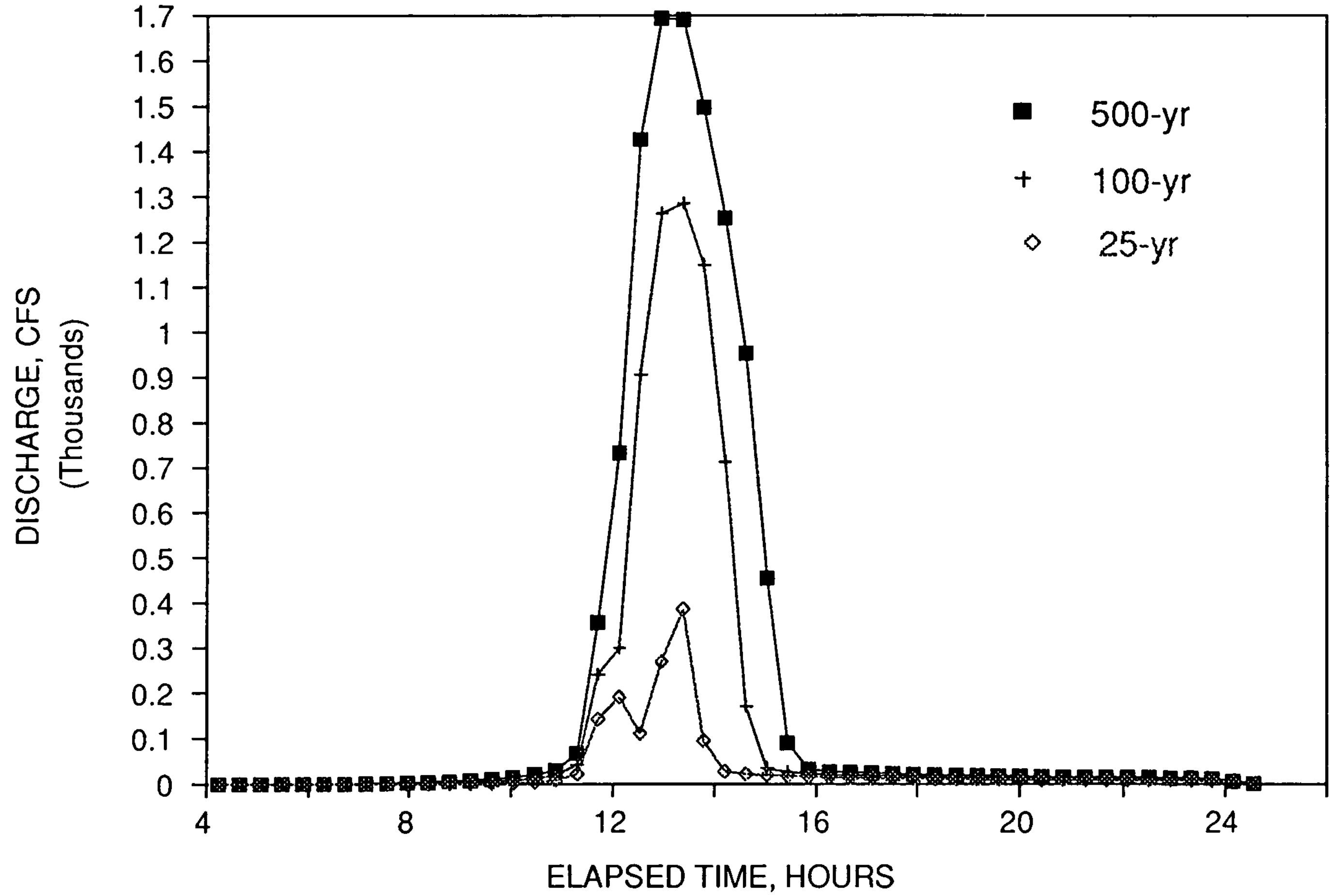


**ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND C-2
(POND EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)**

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 9

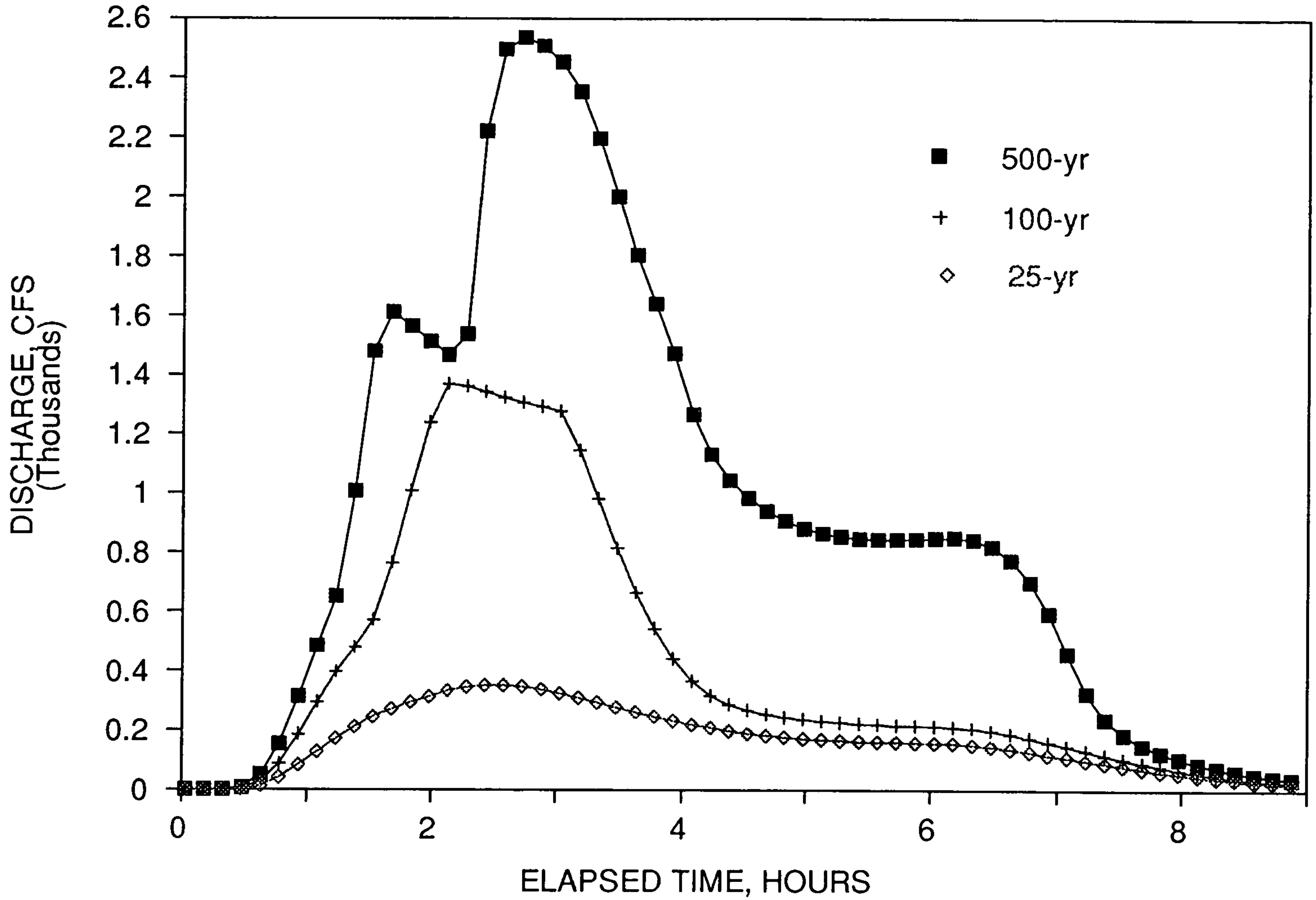


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND C-2
(POND C-2 FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 10

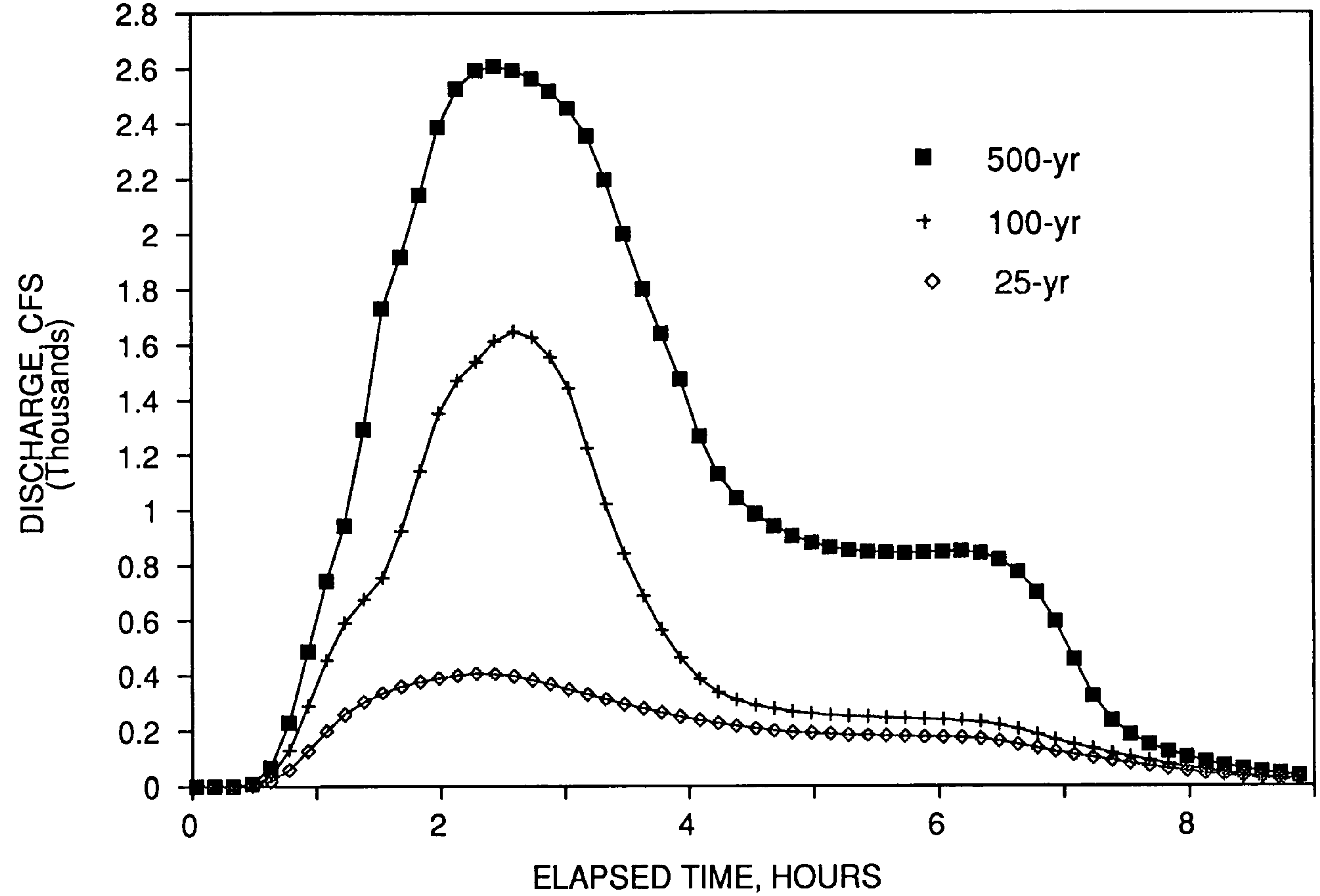


ESTIMATED FLOOD HYDROGRAPHS FOR WOMAN CREEK AT INDIANA STREET (POND C-2 EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 11

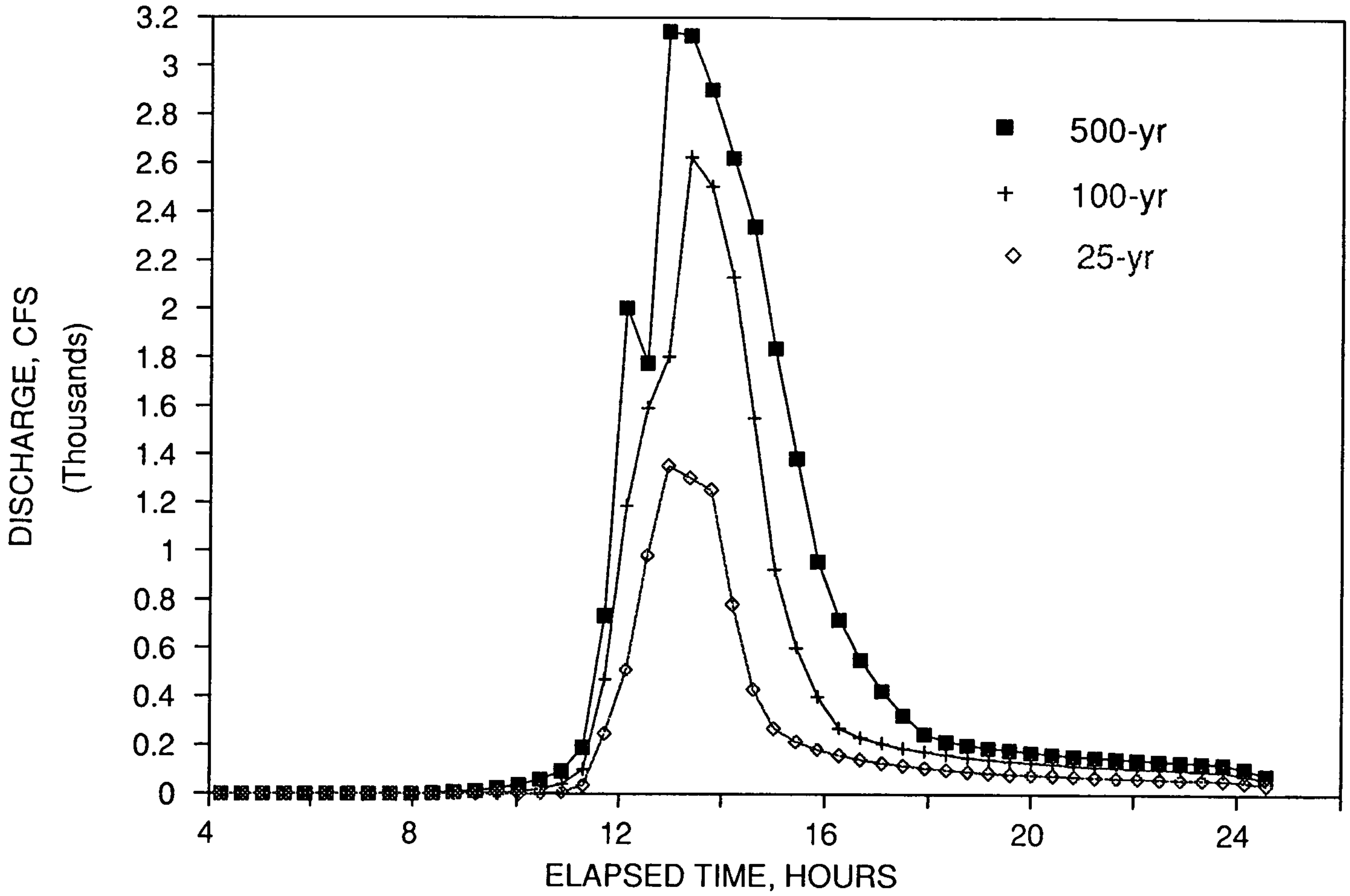


ESTIMATED FLOOD HYDROGRAPHS FOR WOMAN CREEK AT INDIANA STREET (POND C-2 FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 12

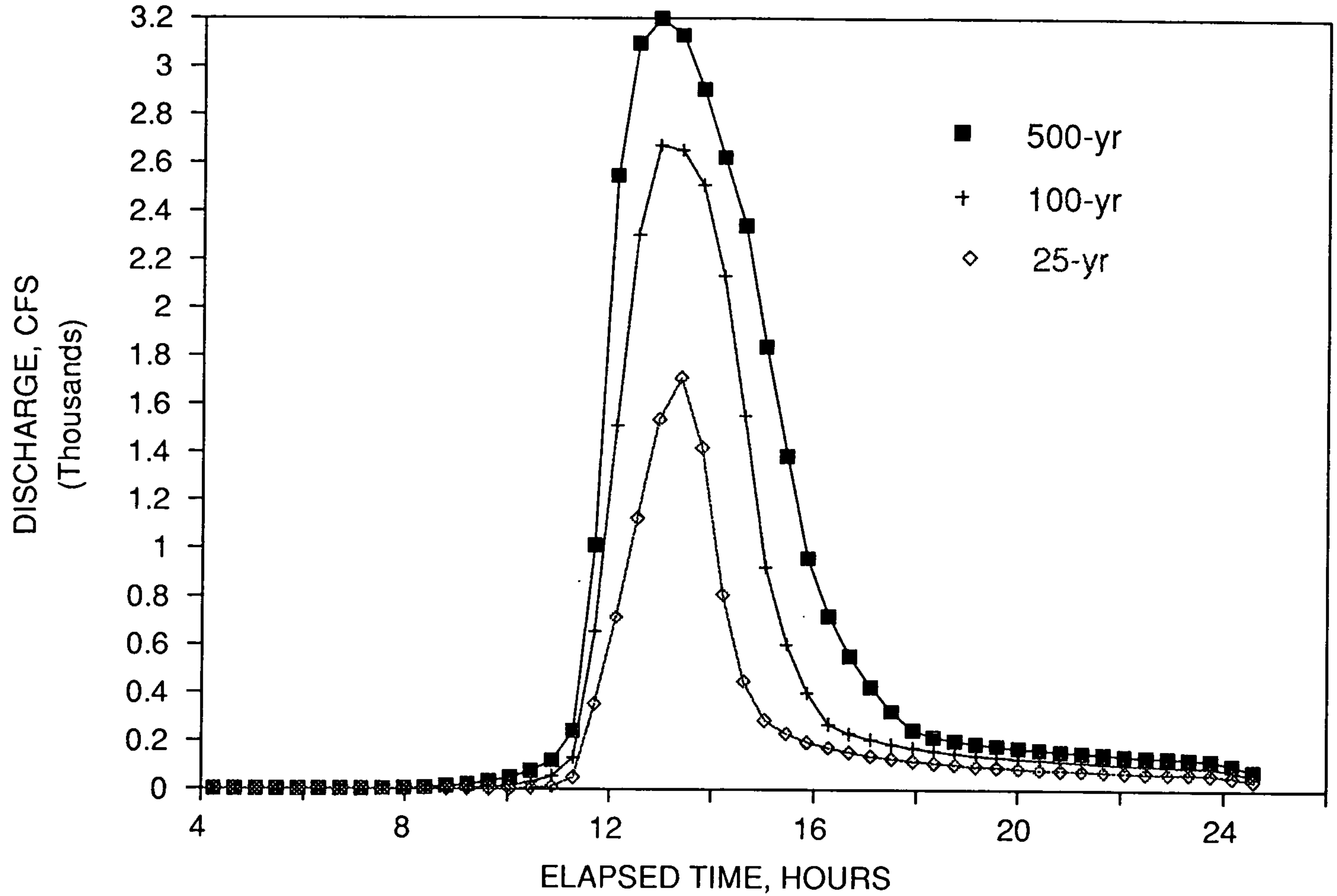


ESTIMATED FLOOD HYDROGRAPHS FOR WOMAN CREEK AT INDIANA STREET (POND C-2 EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 13

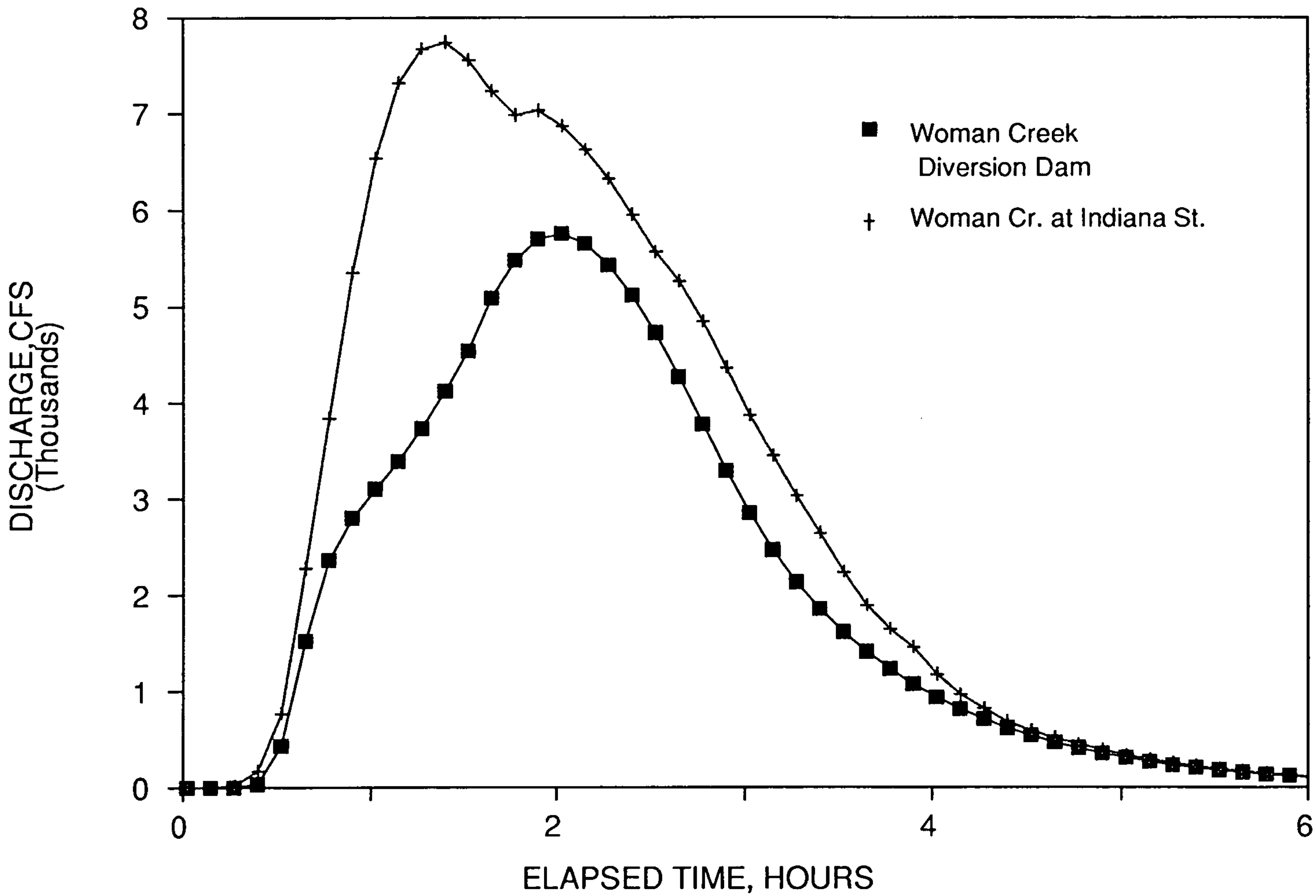


ESTIMATED FLOOD HYDROGRAPHS FOR WOMAN CREEK AT INDIANA STREET (POND C-2 FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 14

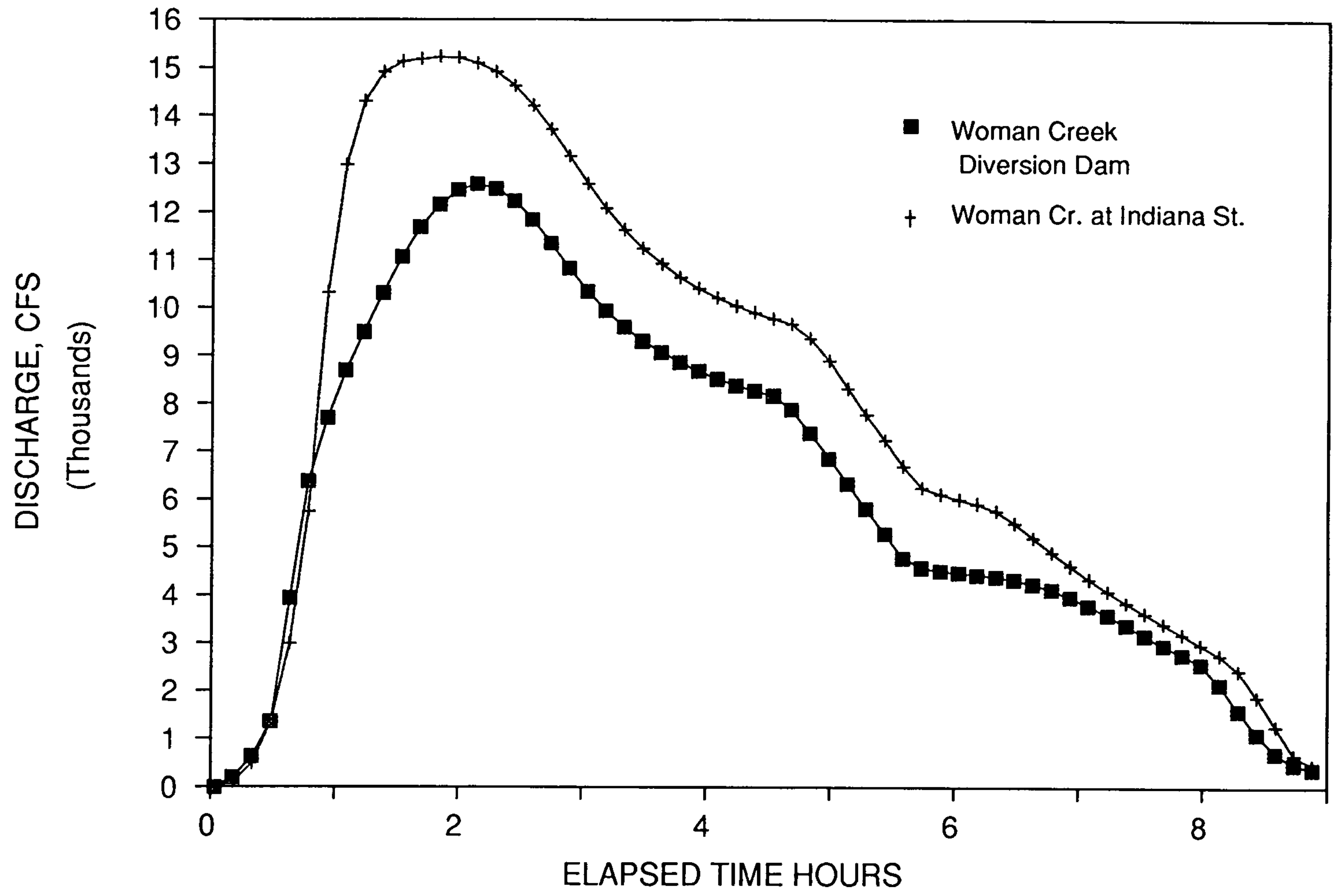


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED WOMAN CREEK BASIN LOCATIONS (1-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 15

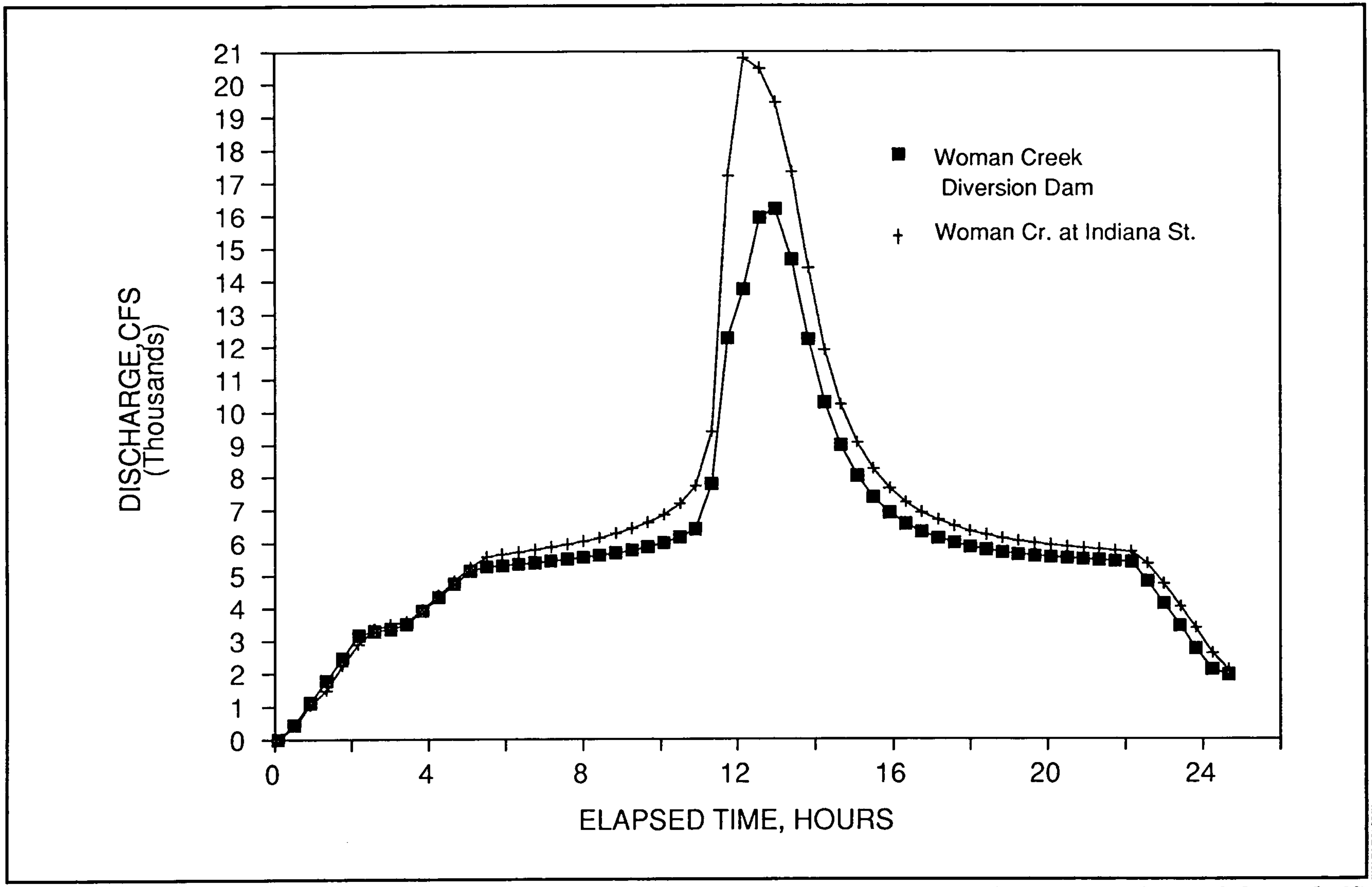


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED WOMAN CREEK BASIN LOCATIONS (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 16

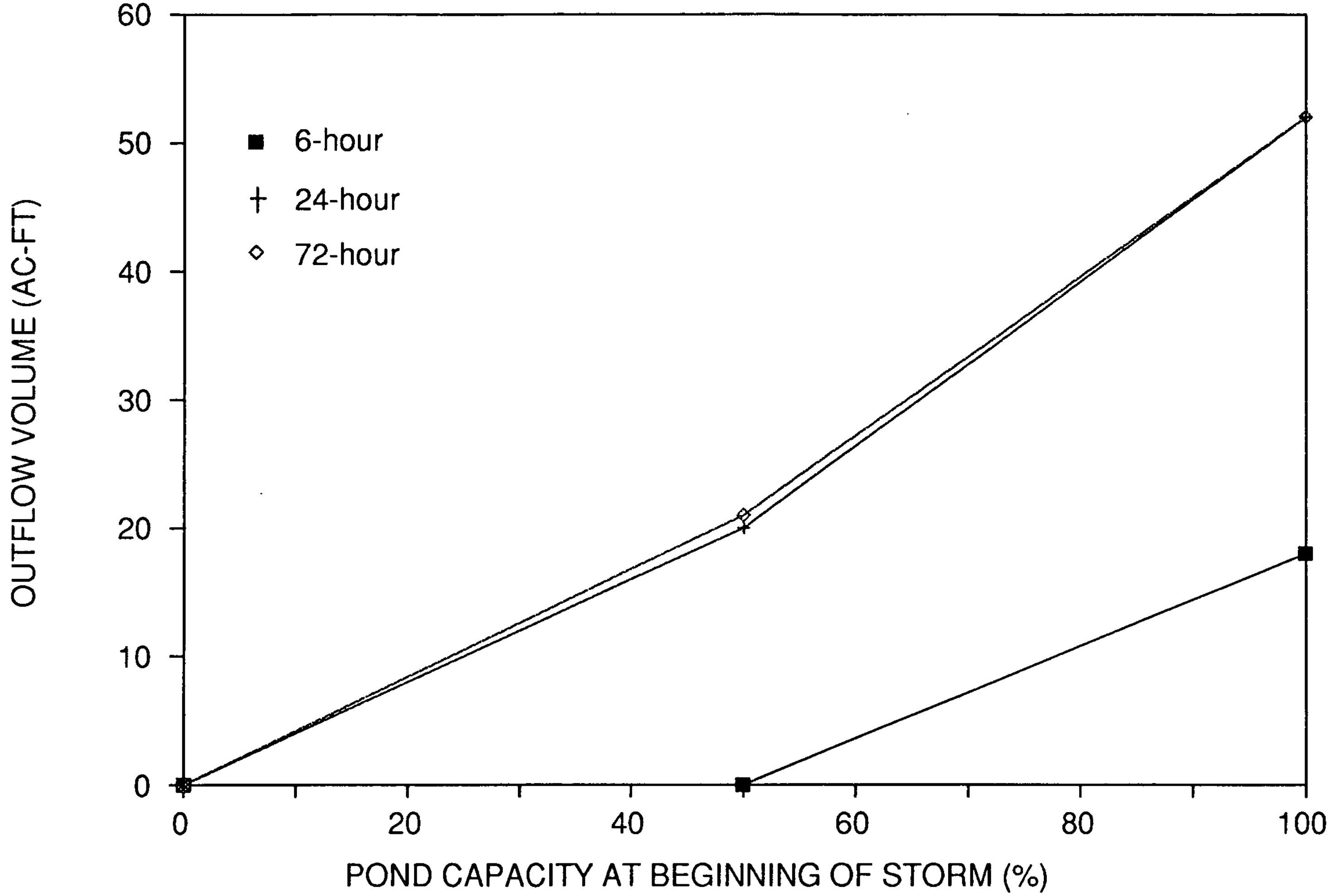


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED WOMAN CREEK BASIN LOCATIONS (24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 17

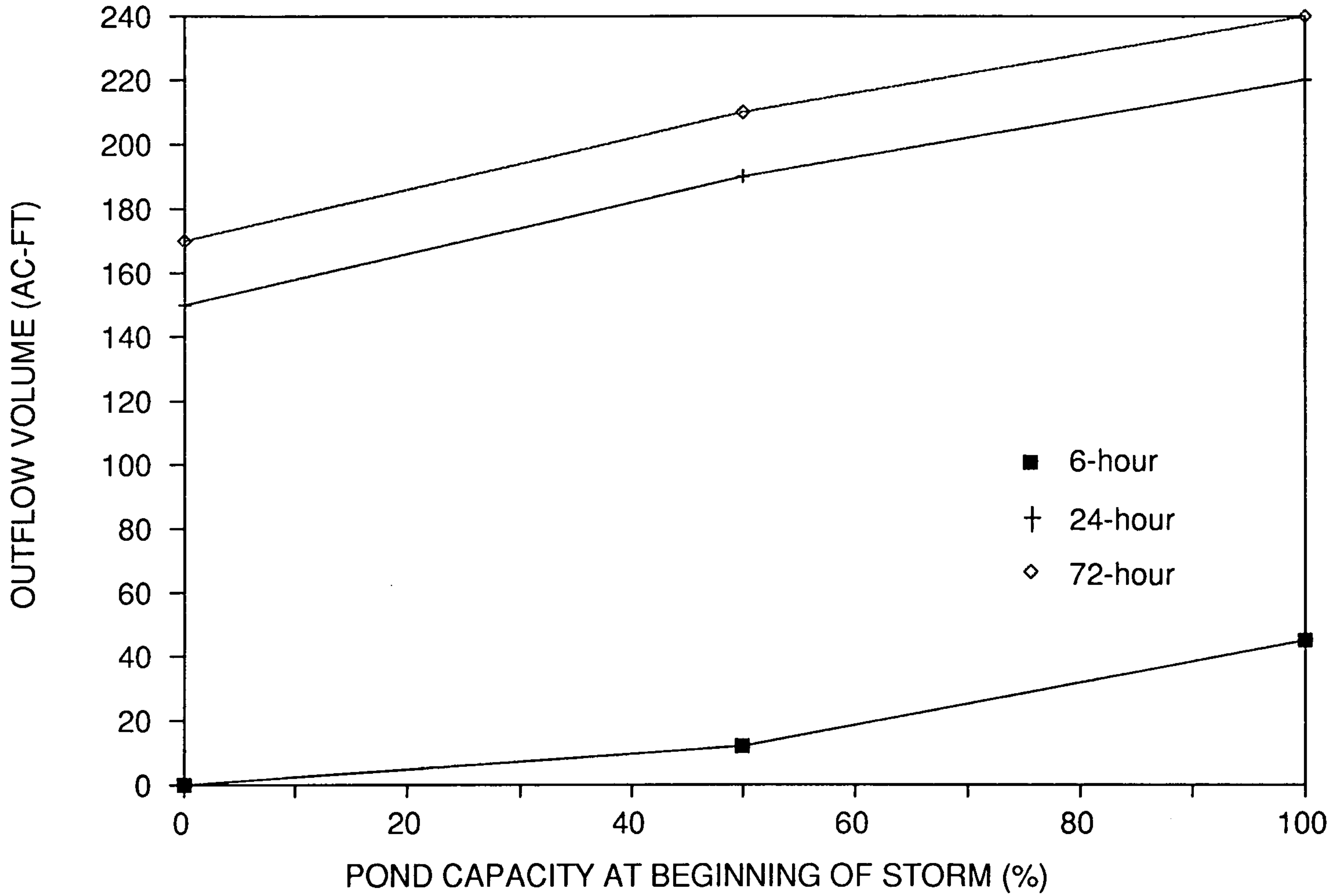


ESTIMATED POND C-2 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (25-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 18

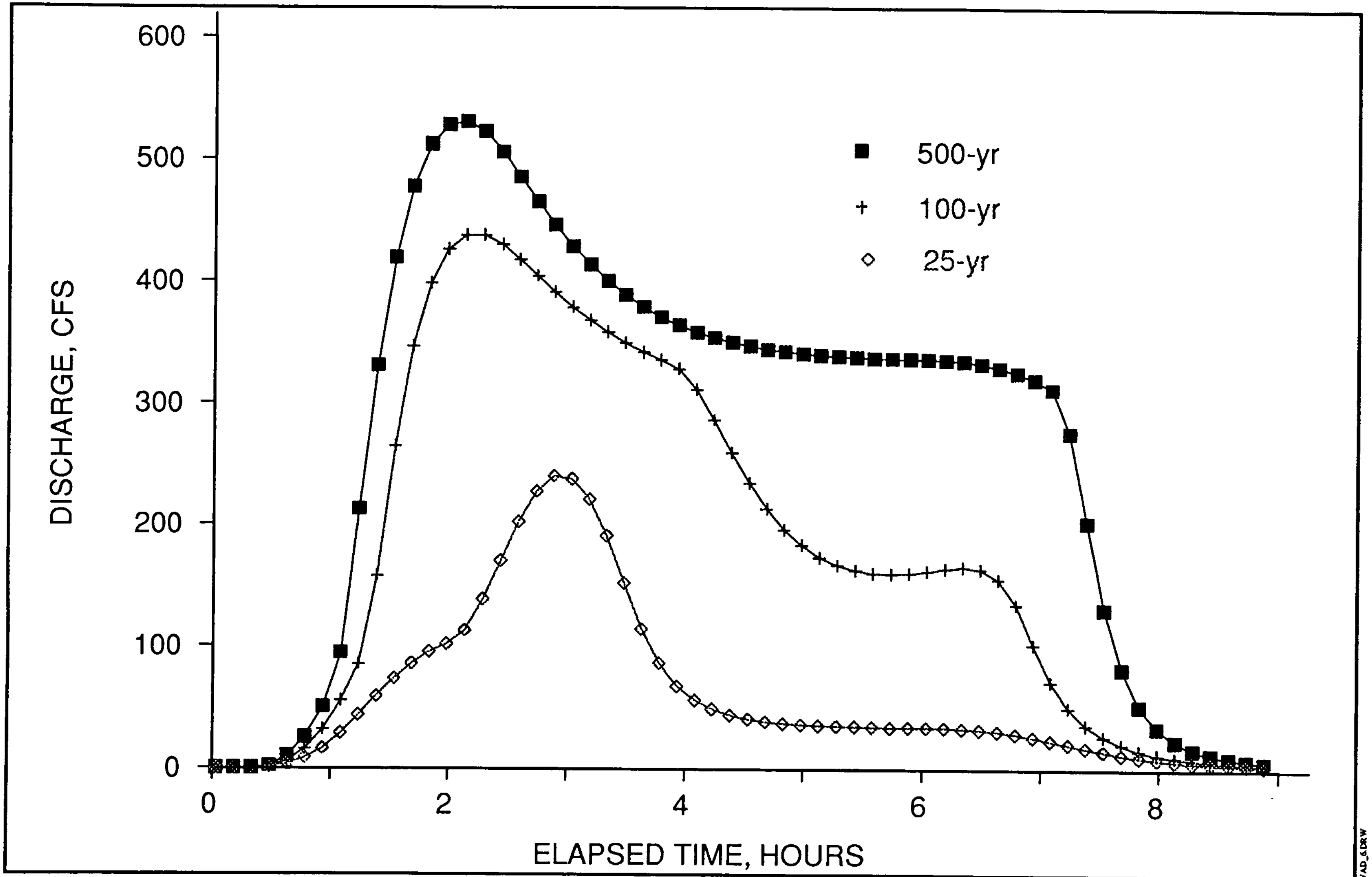


ESTIMATED POND C-2 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (100-YEAR STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 19

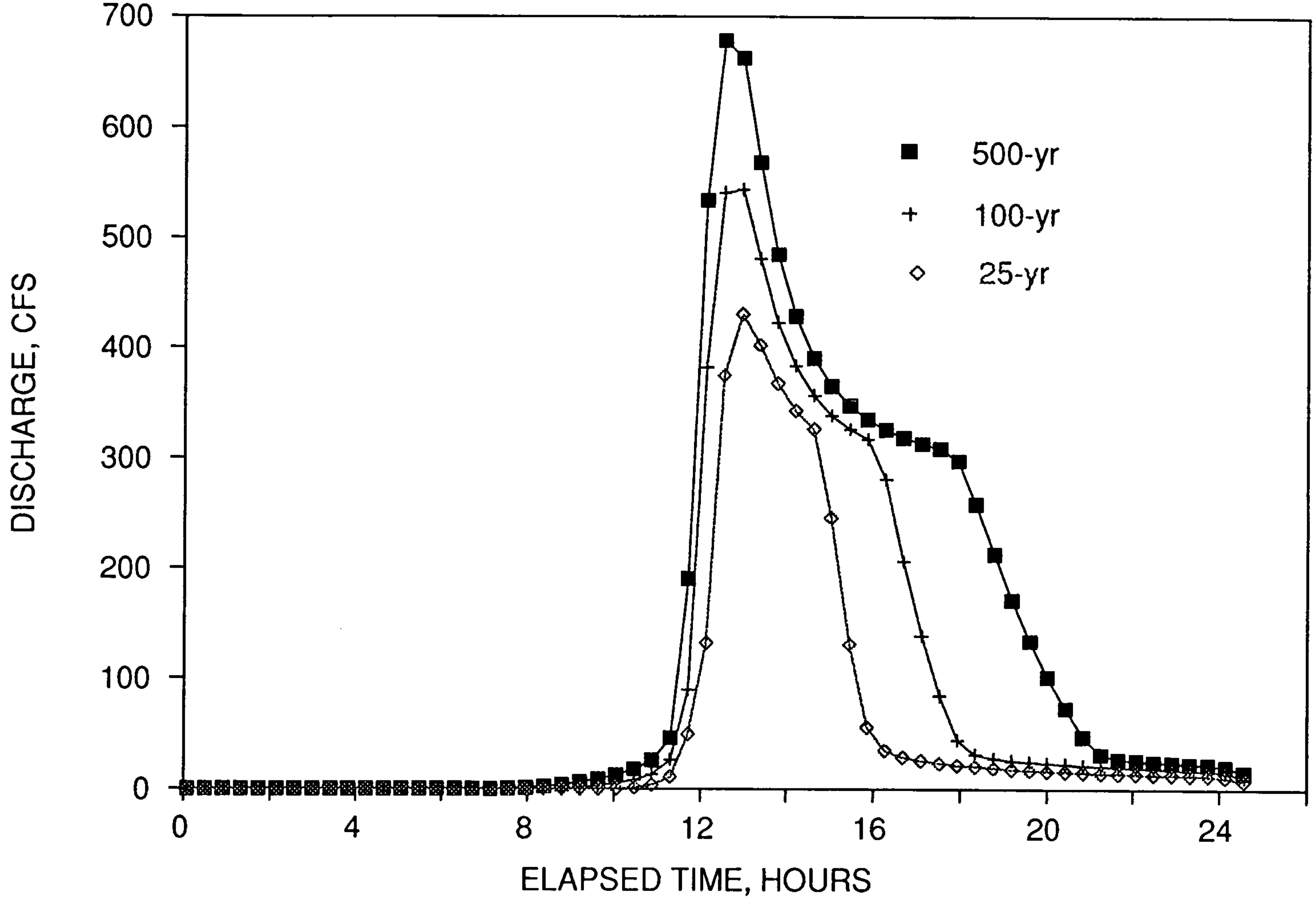


ESTIMATED FLOOD HYDROGRAPHS AT THE N. WALNUT CREEK DIVERSION DAM (6-HOUR DURATION)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 21

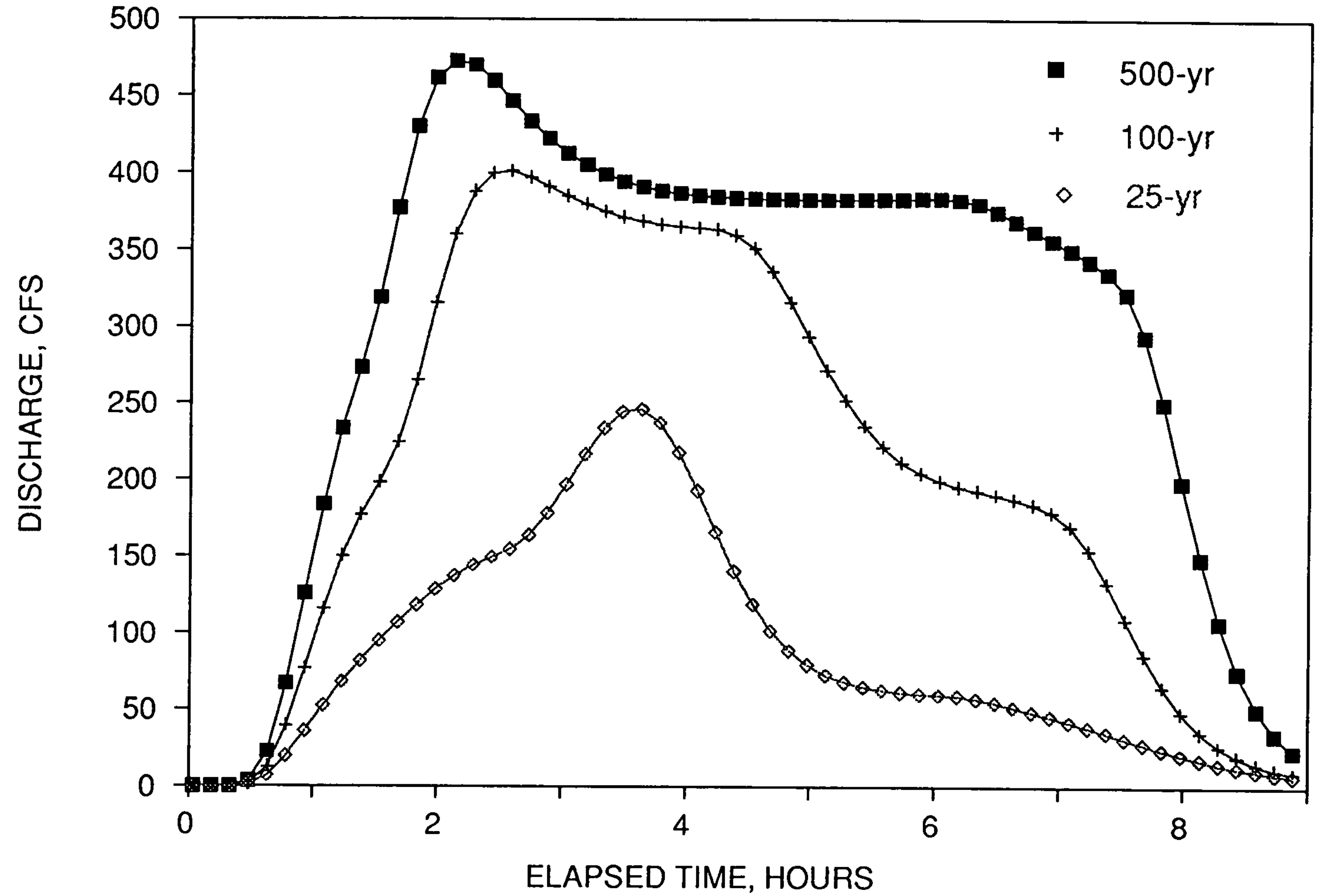


ESTIMATED FLOOD HYDROGRAPHS FOR THE NORTH WALNUT CREEK DIVERSION DAM (24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 22

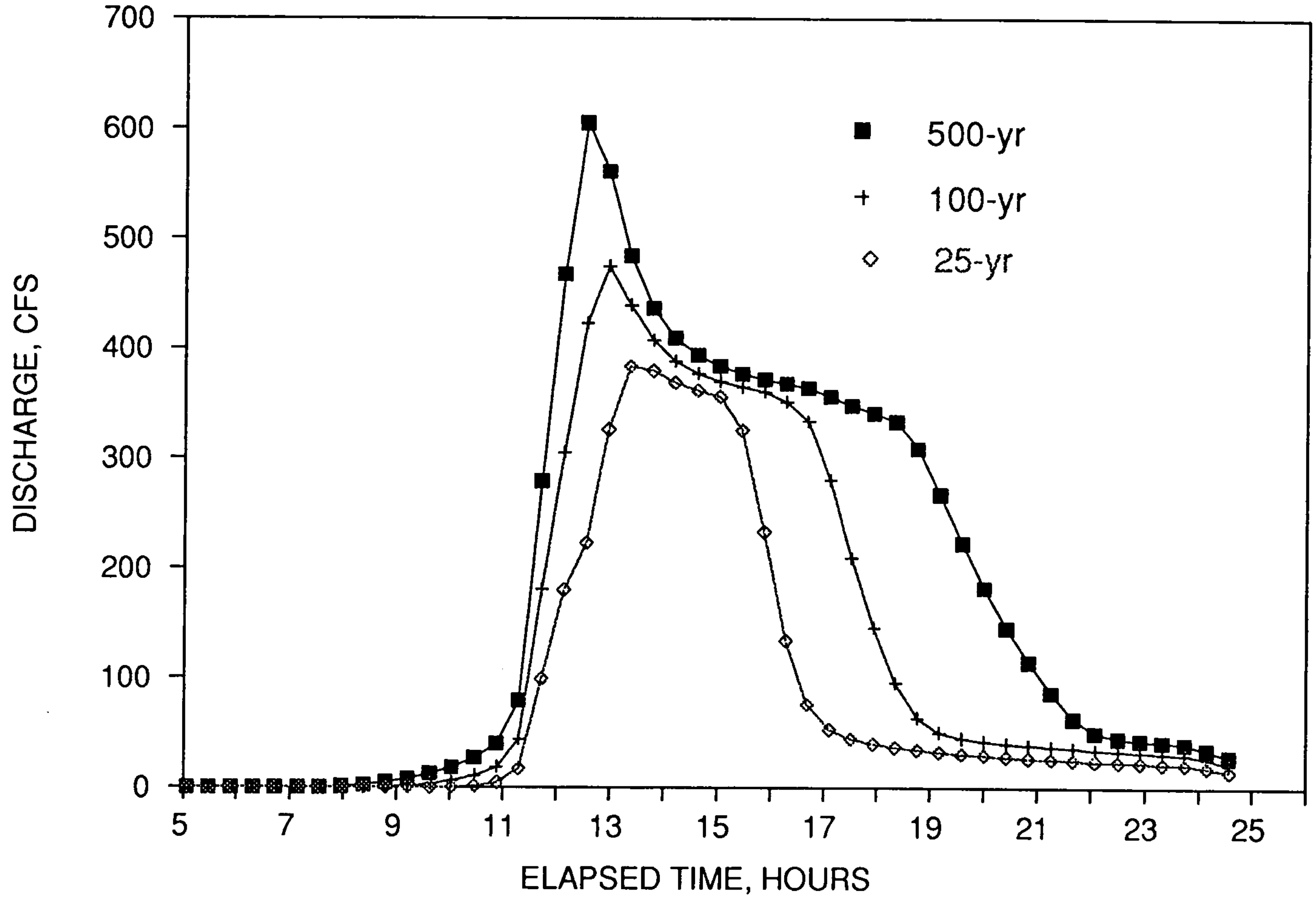


ESTIMATED FLOOD HYDROGRAPHS FOR THE MCKAY BYPASS DITCH (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 23

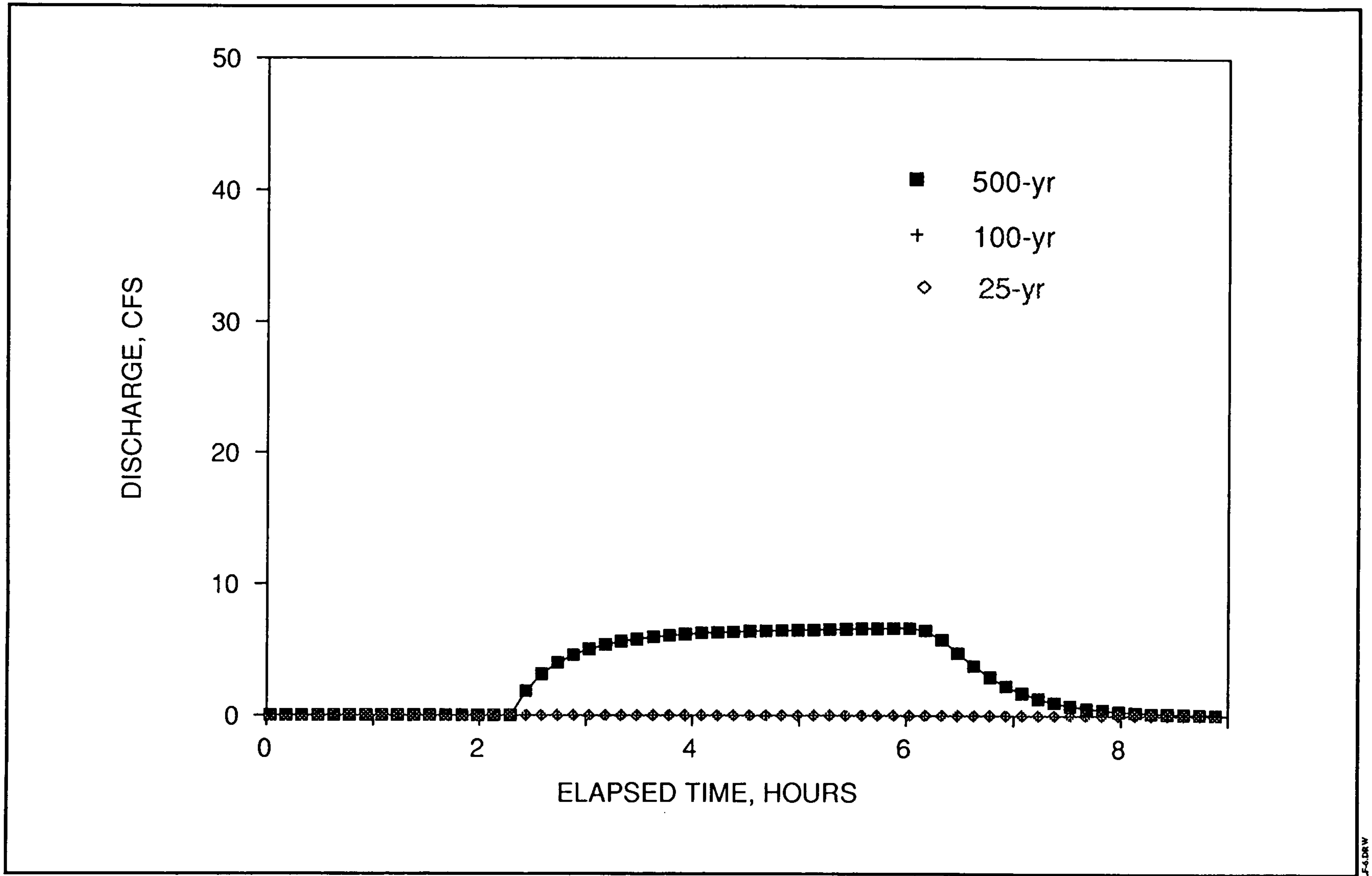


ESTIMATED FLOOD HYDROGRAPHS FOR THE MCKAY BYPASS DITCH (24-HOUR DURATION)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 24

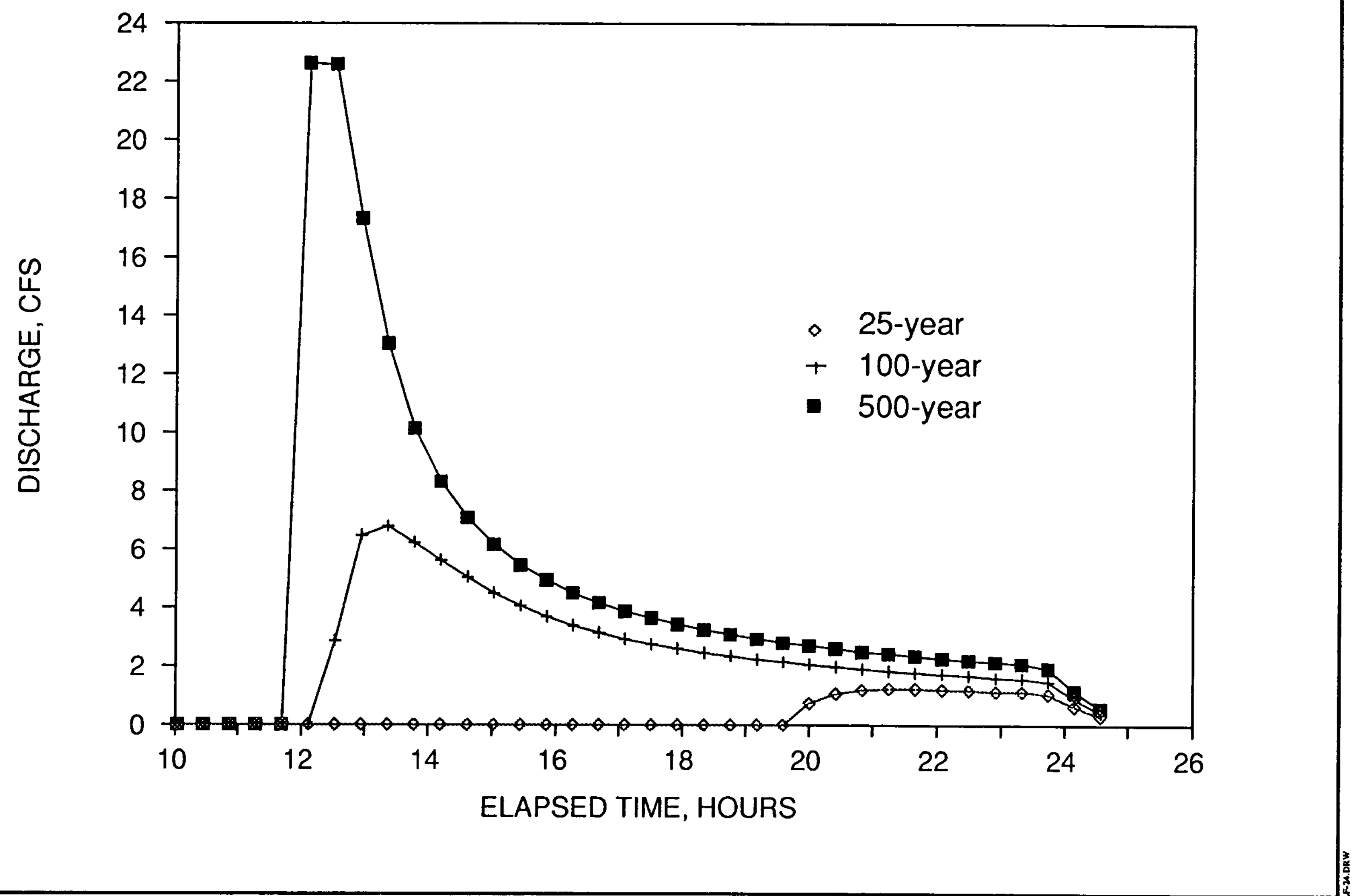


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR THE LANDFILL RESERVOIR (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 25

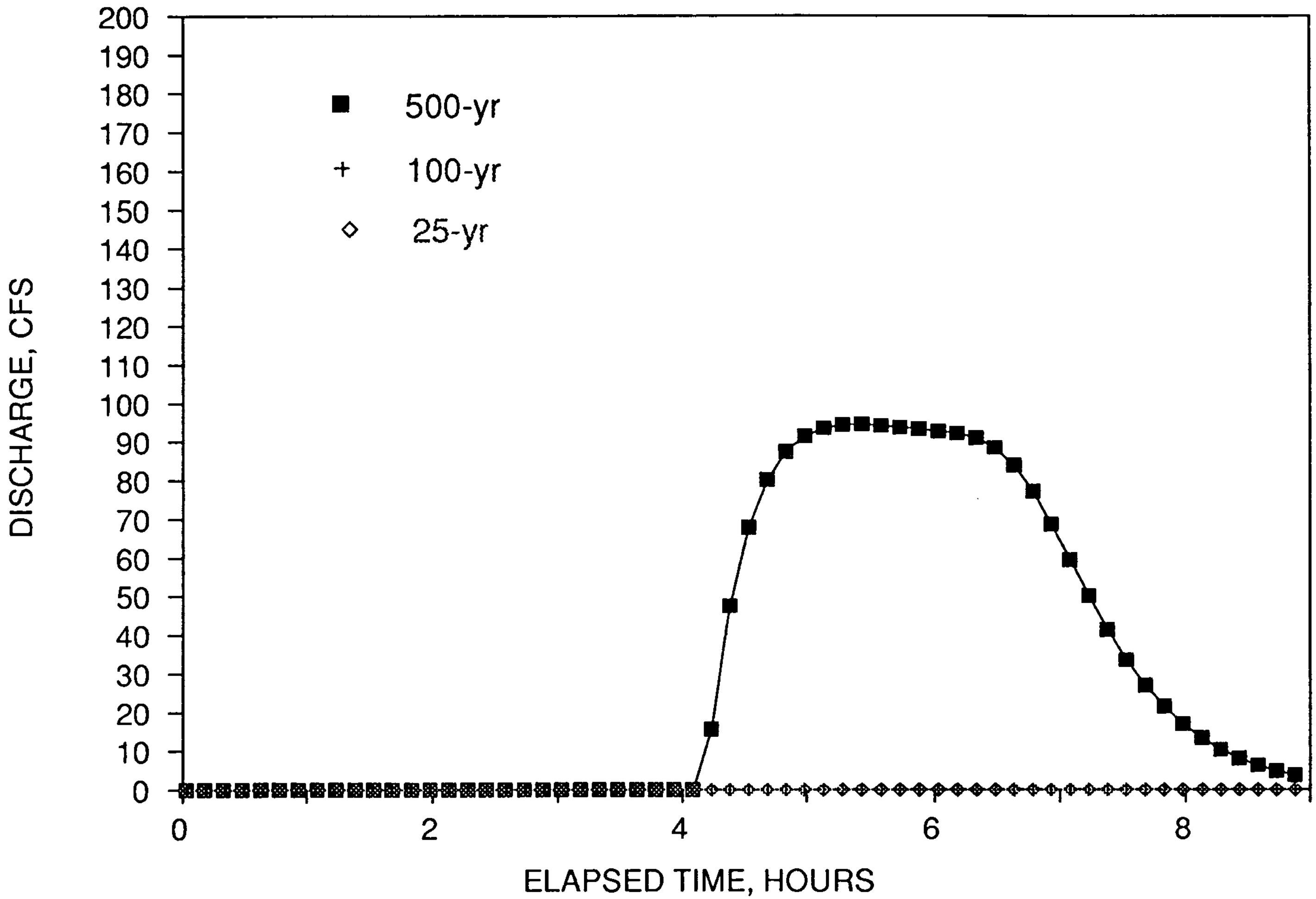


ESTIMATED FLOOD HYDROGRAPHS FOR THE LANDFILL RESERVOIR (24-HOUR DURATION)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 26

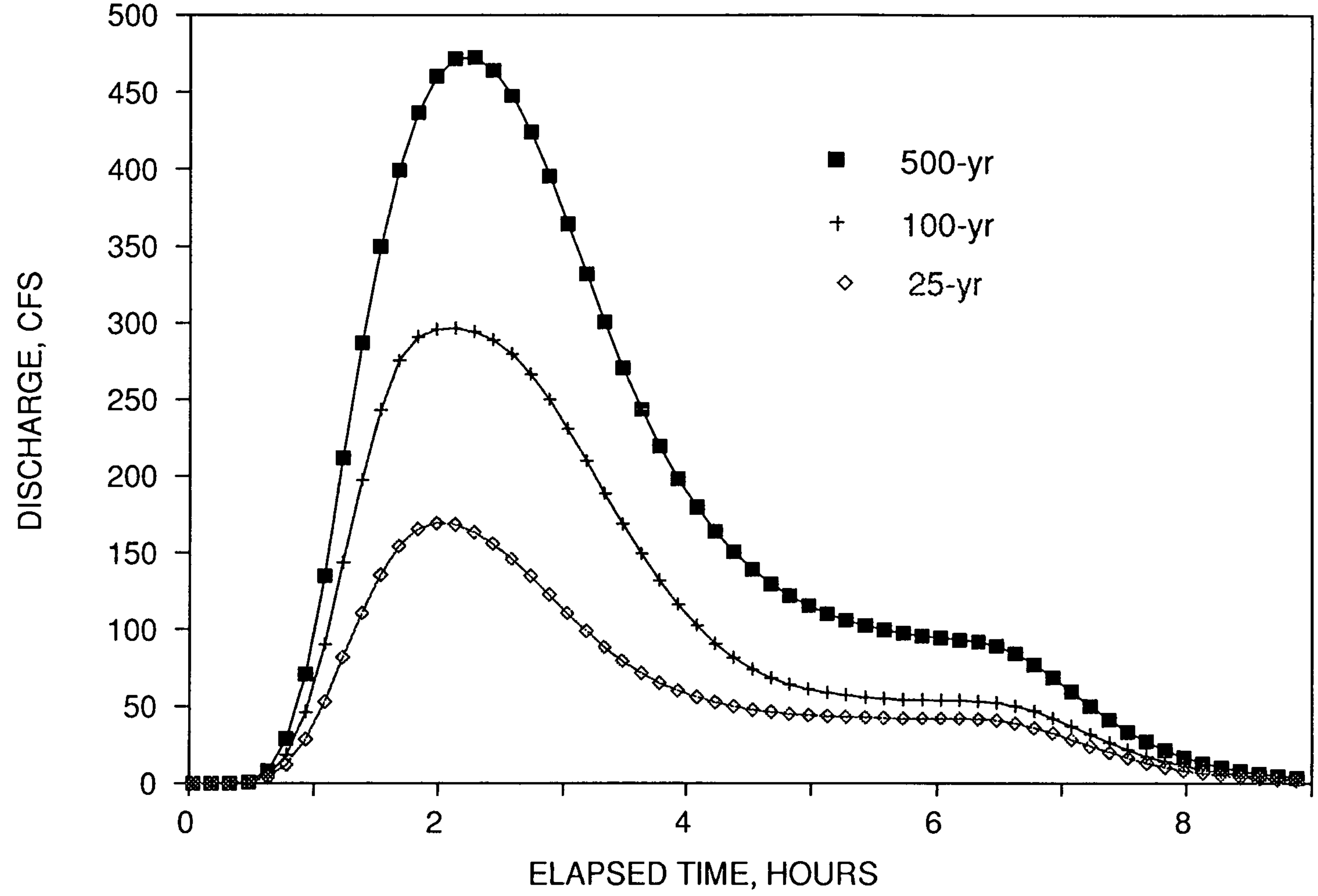


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND A-4 (POND EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 27

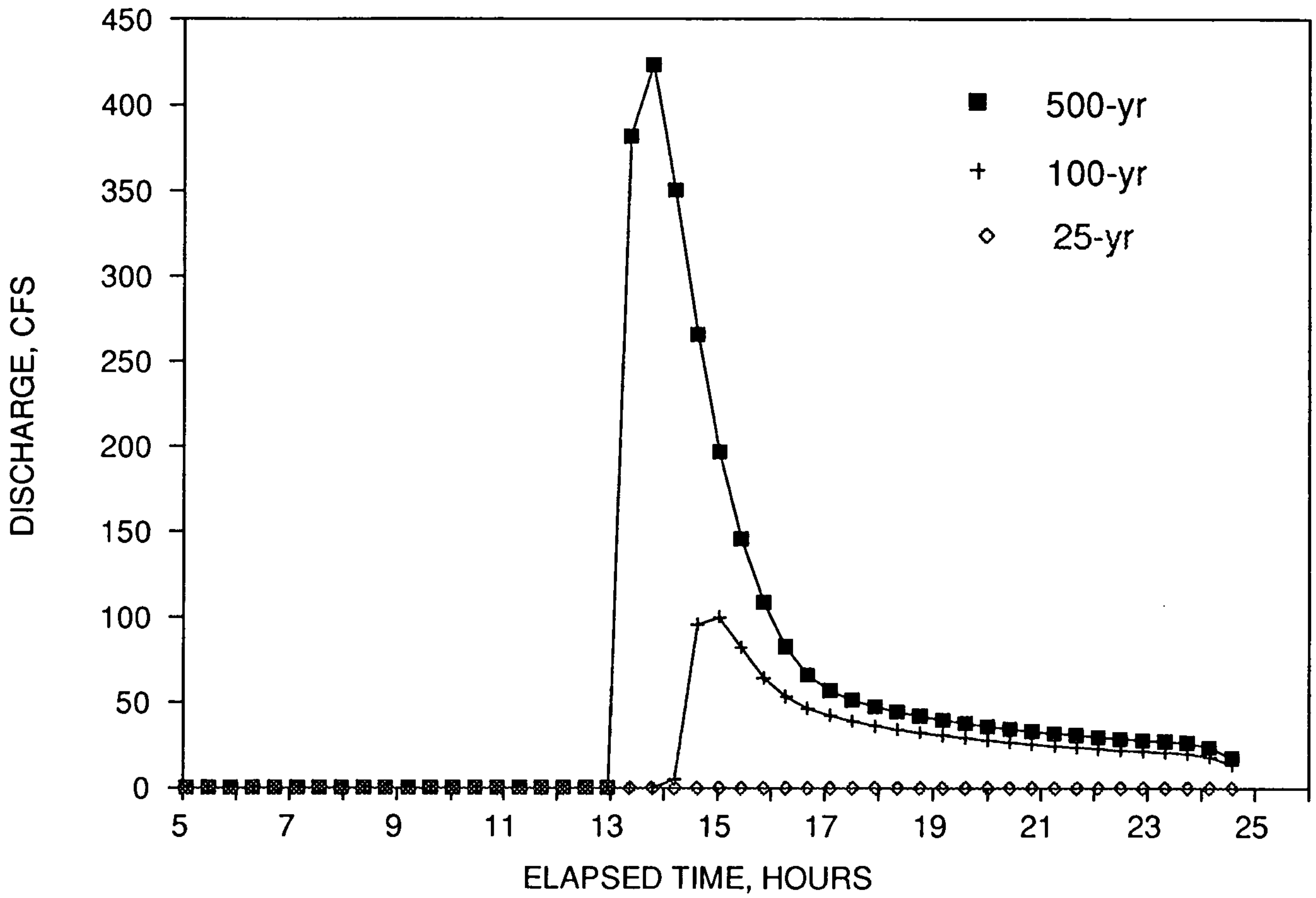


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND A-4
(POND FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 28

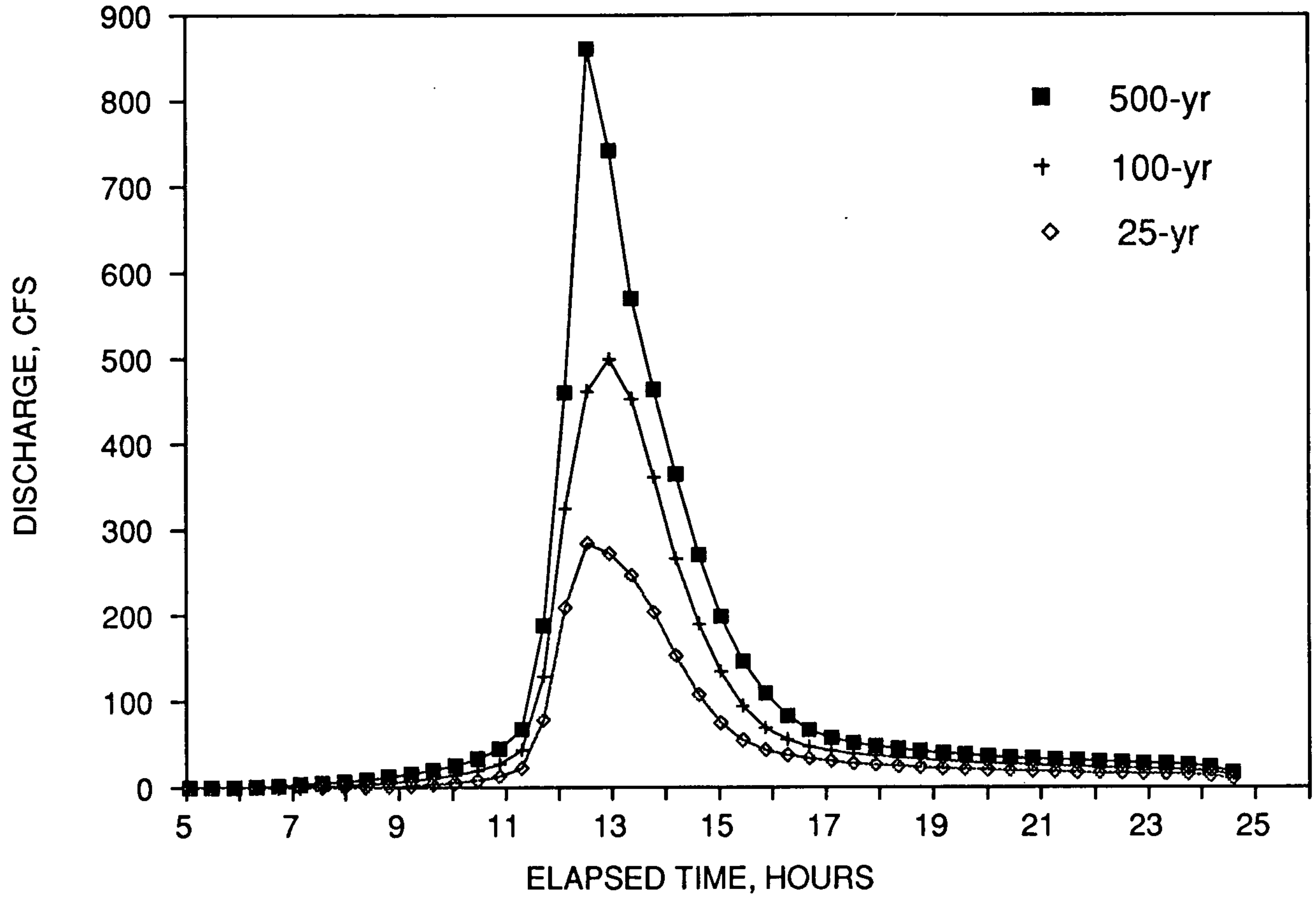


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND A-4 (POND EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 29

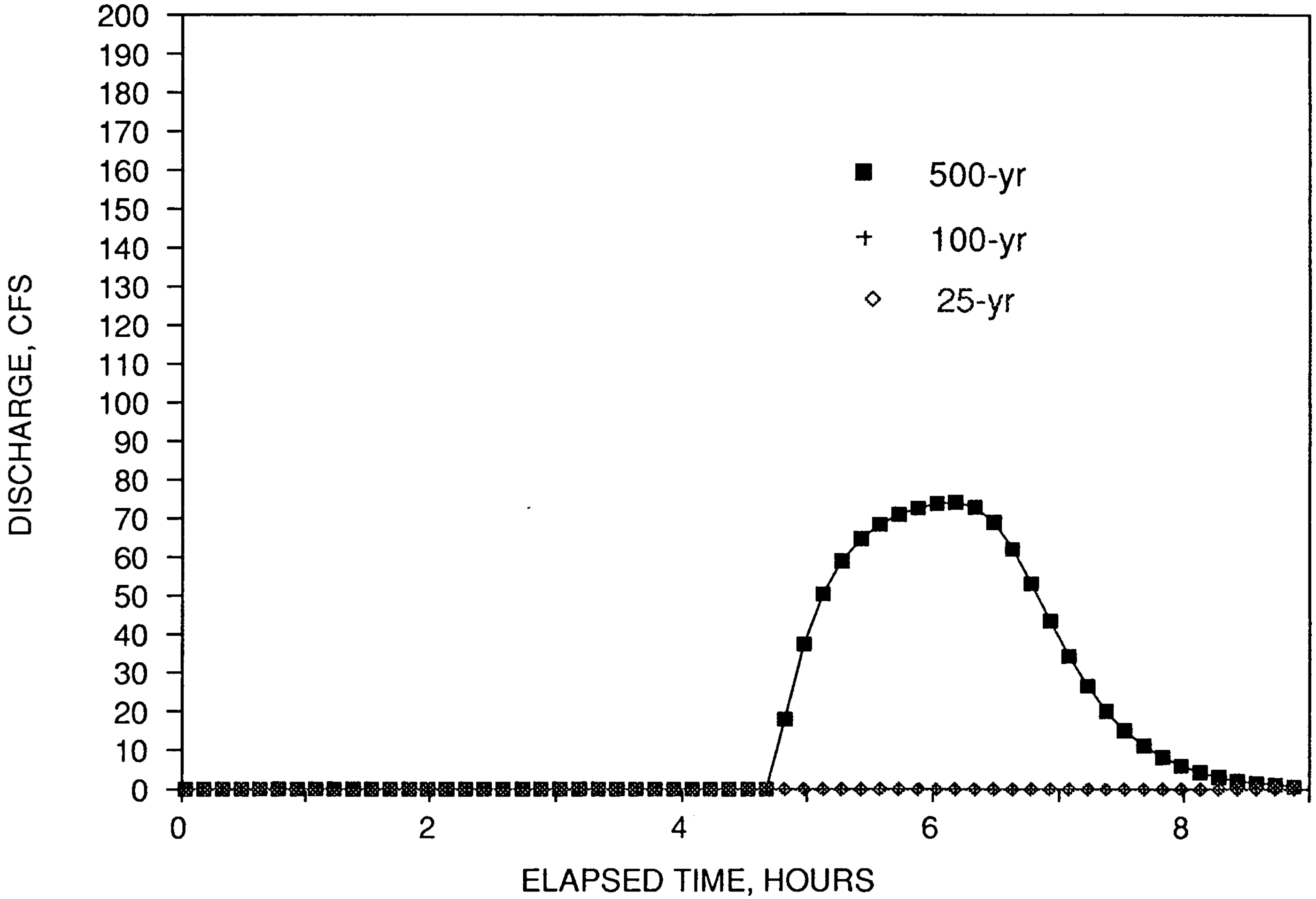


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND A-4
(POND FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 30



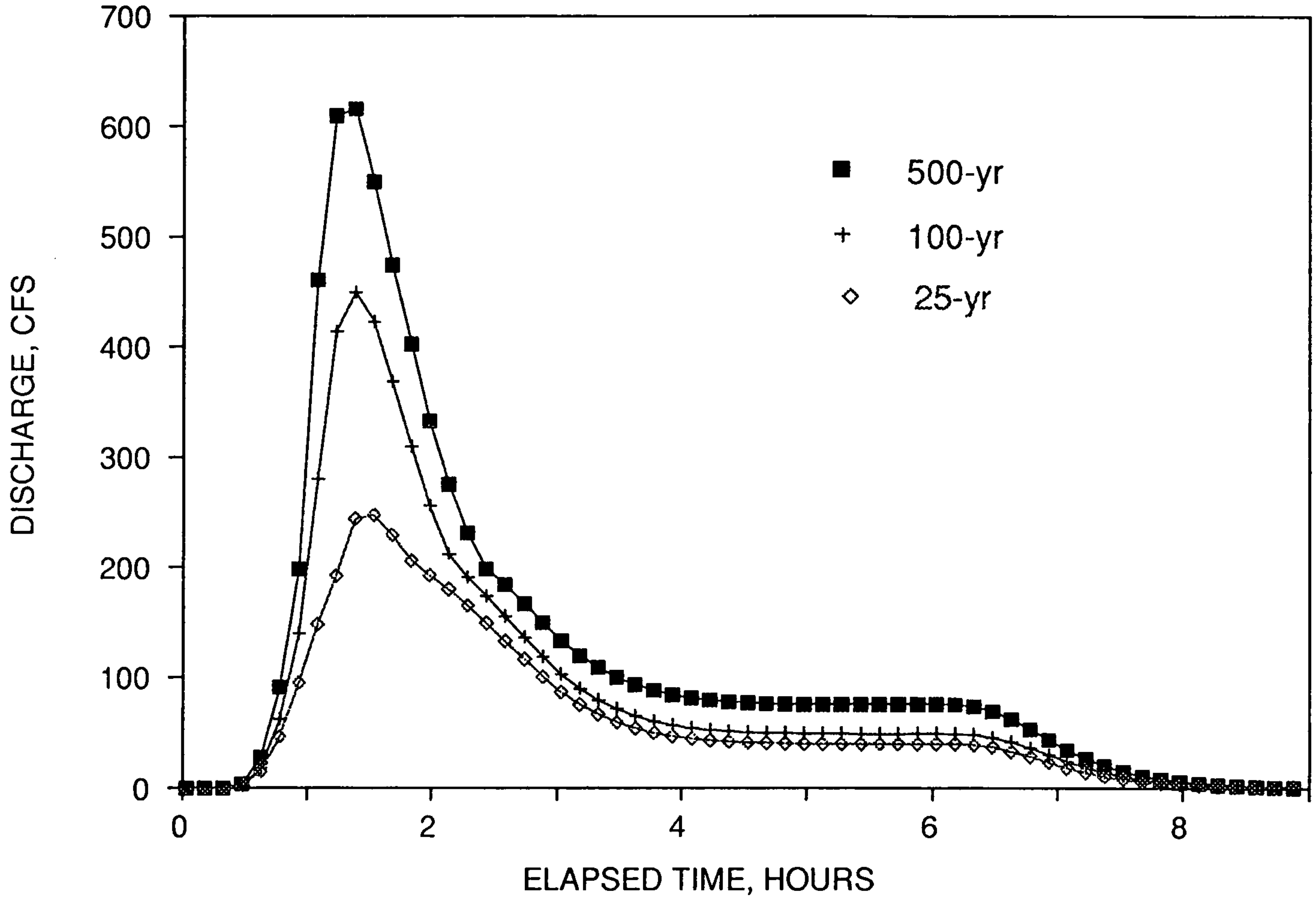
B-5-6E.DRW

ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND B-5
(POND EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 31

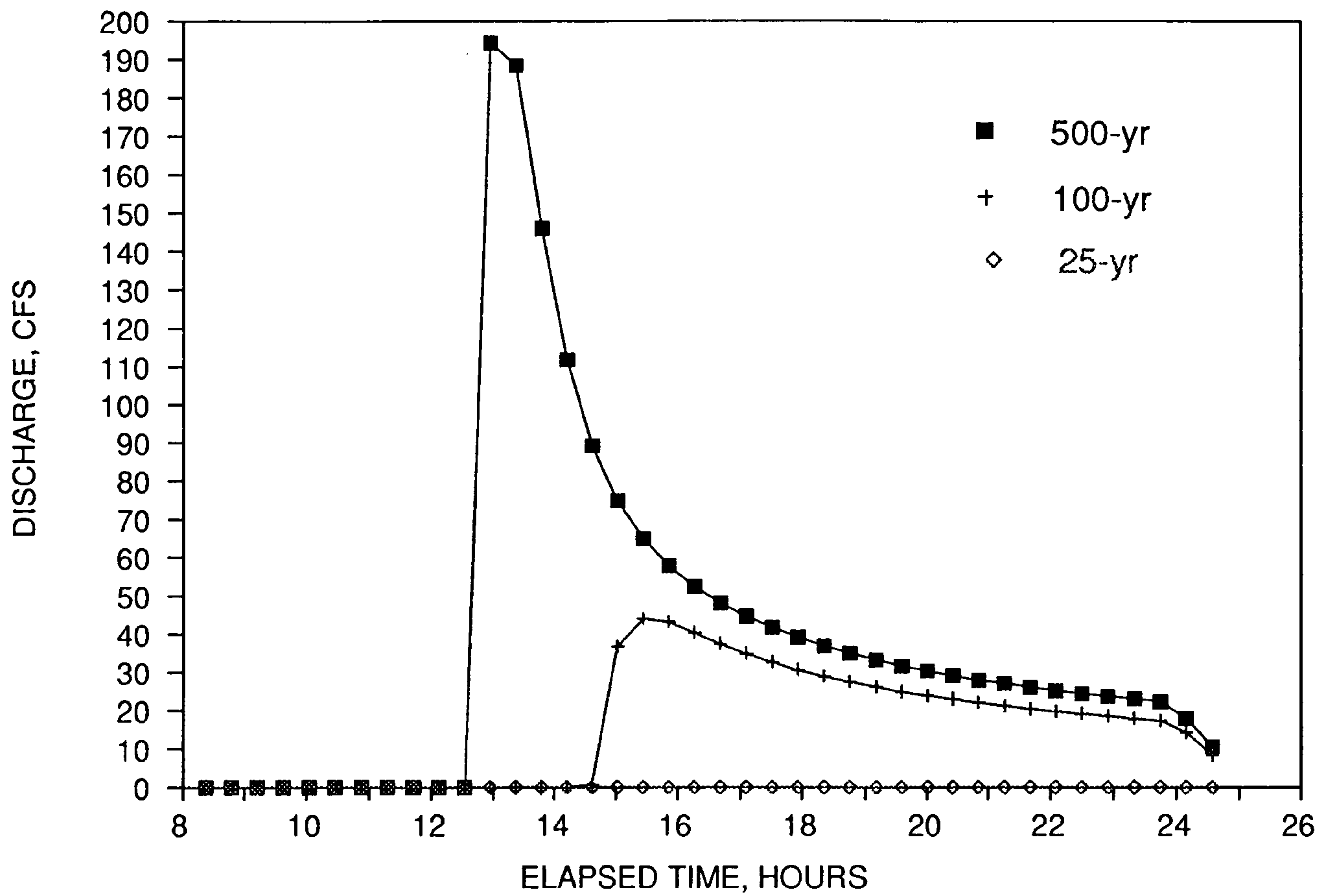


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND B-5
(POND FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 32

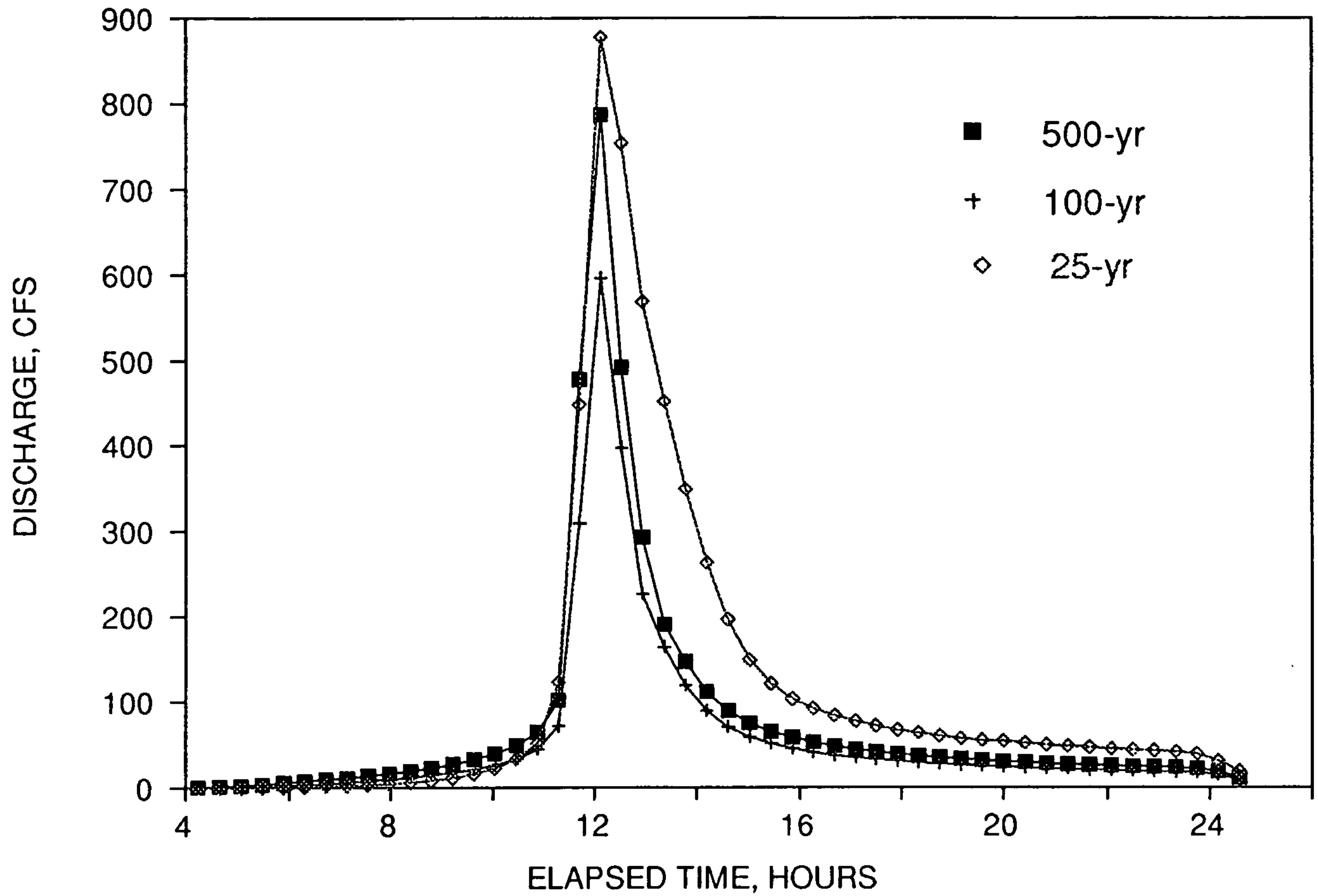


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND B-5
(POND EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 33



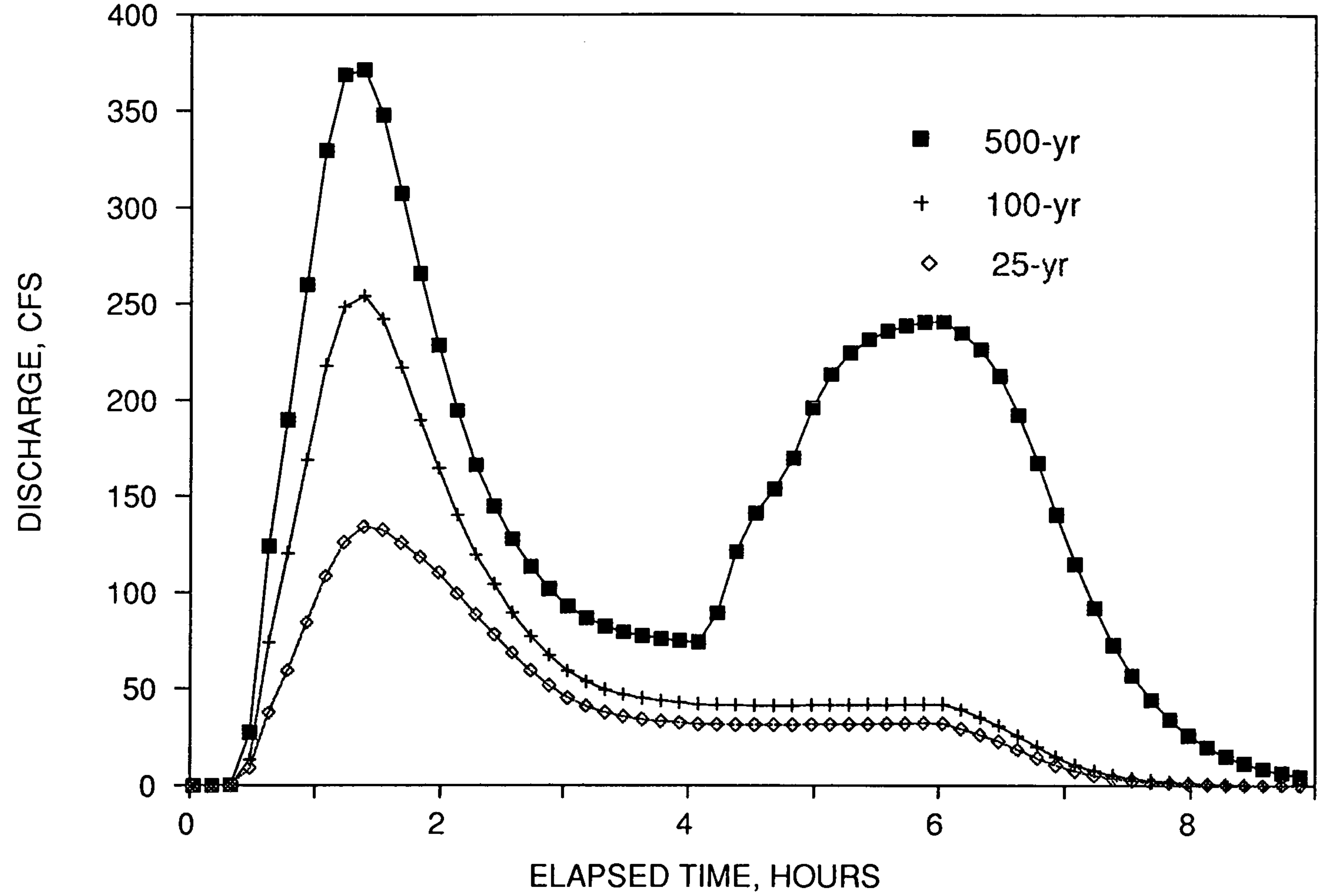
B-5-34F.DRW

ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR POND B-5
(POND FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 34

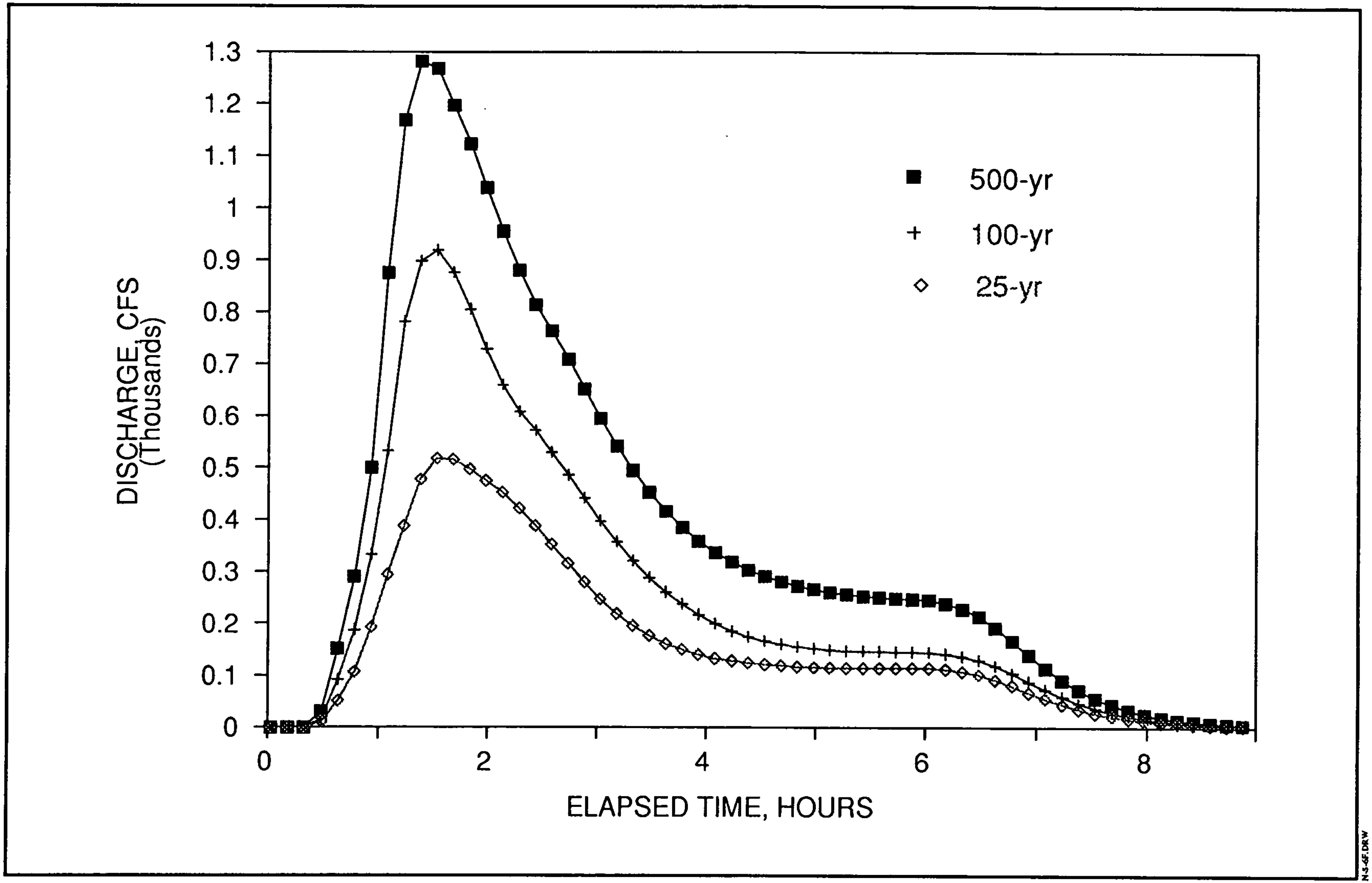


ESTIMATED FLOOD HYDROGRAPHS FOR THE CONFLUENCE OF NORTH AND SOUTH WALNUT CREEKS (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 35

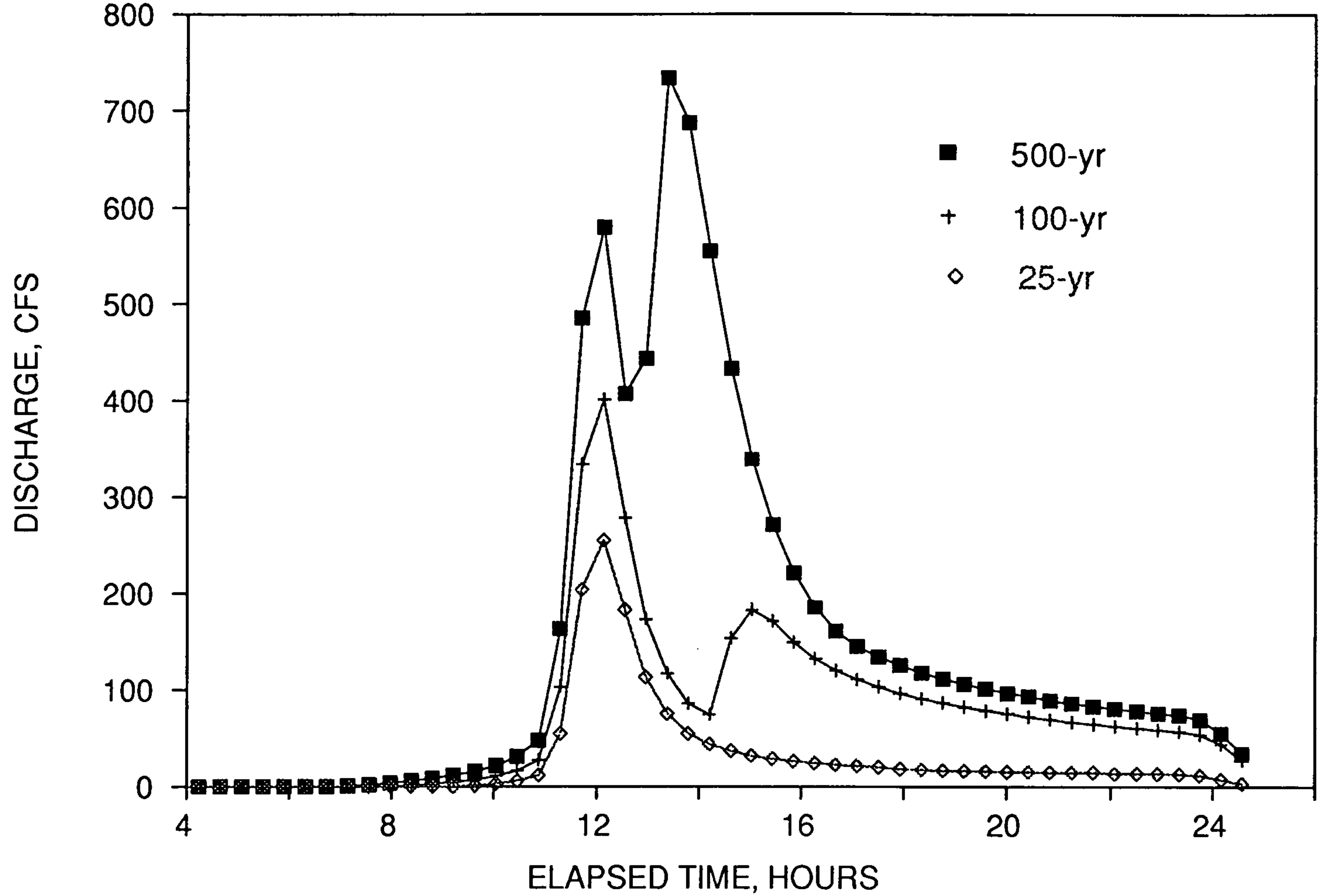


ESTIMATED FLOOD HYDROGRAPHS FOR CONFLUENCE OF NORTH AND SOUTH WALNUT CREEKS (PONDS A-4 AND B-5 FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 36

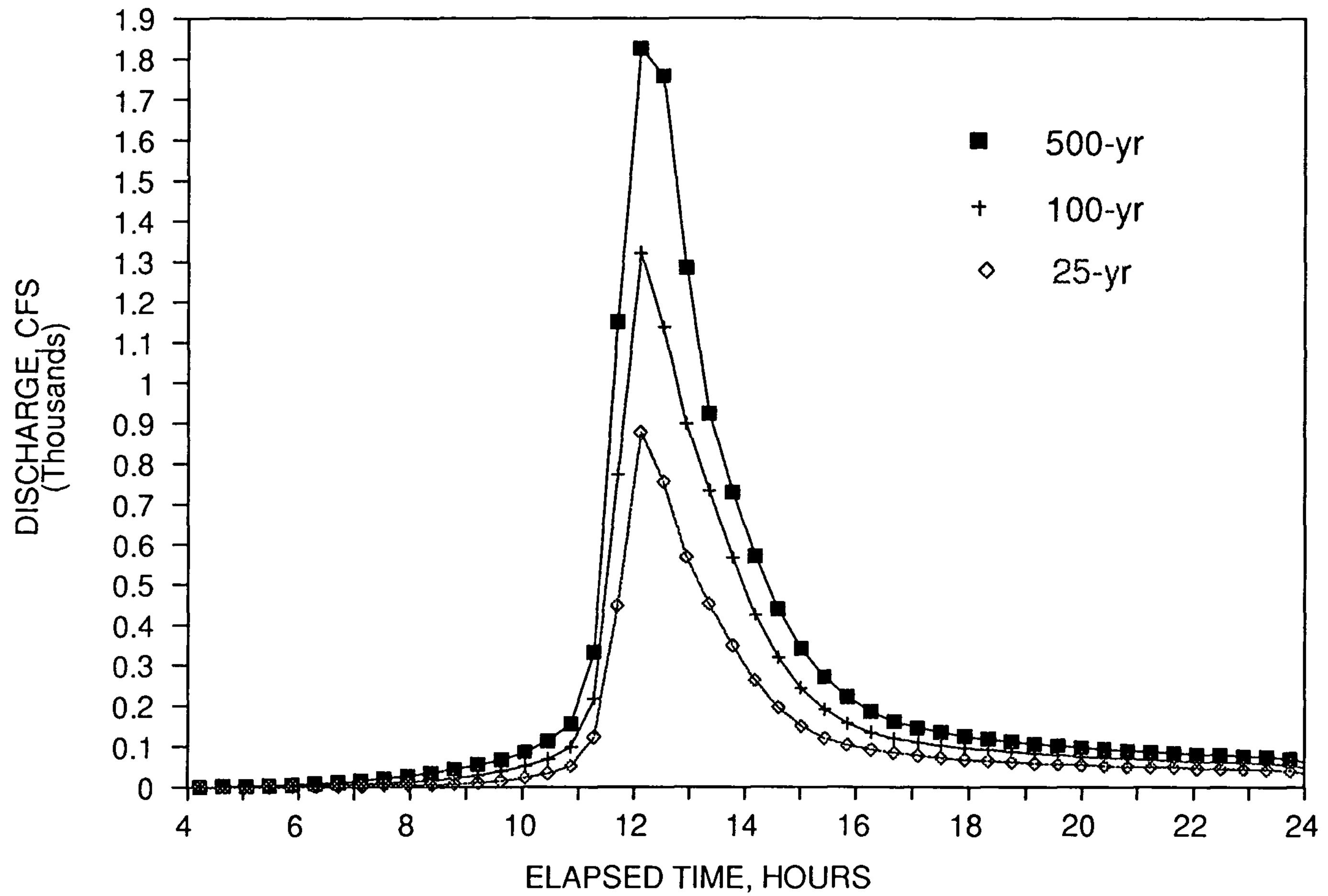


ESTIMATED FLOOD HYDROGRAPHS FOR THE CONFLUENCE OF NORTH AND SOUTH WALNUT CREEKS (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 37

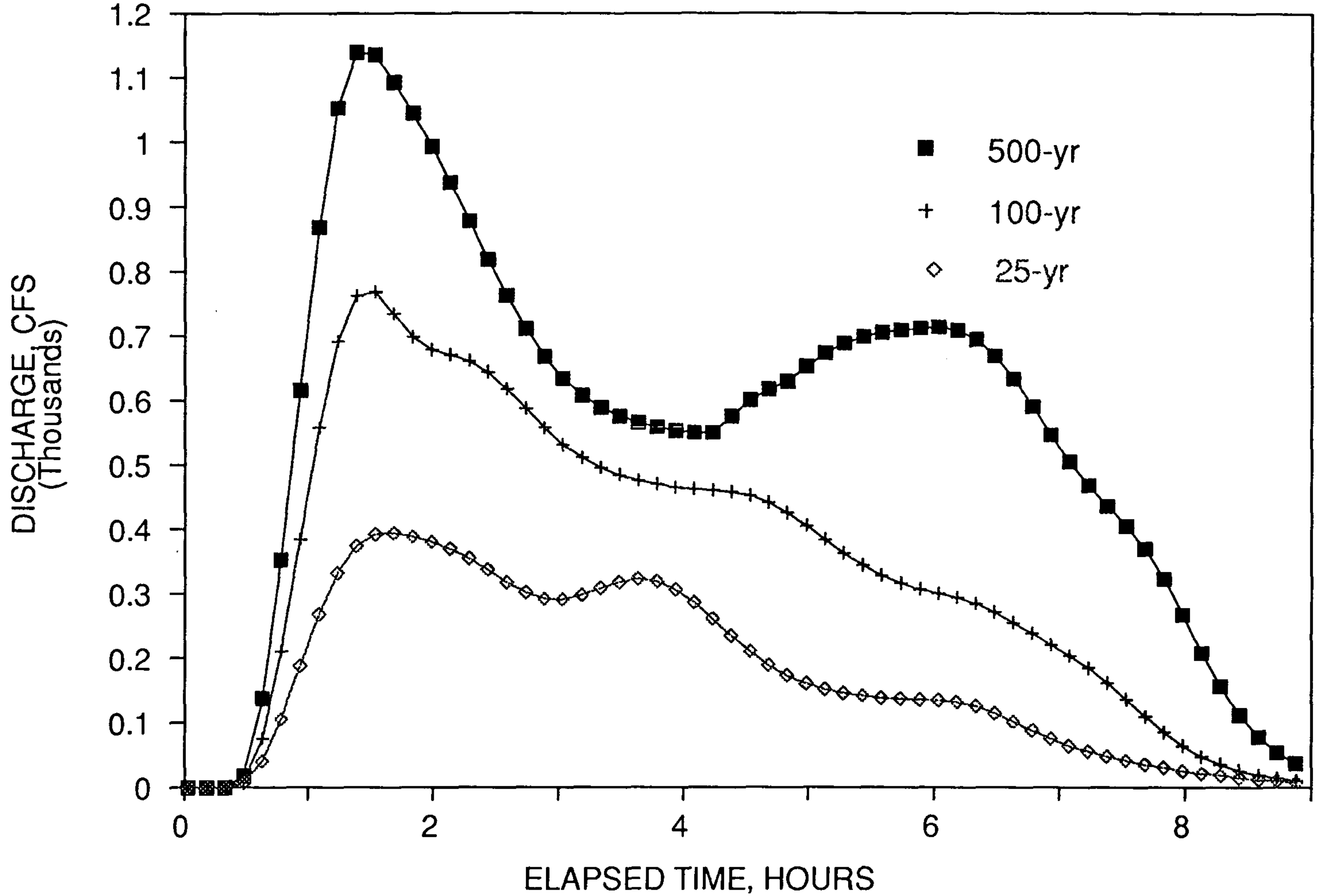


ESTIMATED FLOOD HYDROGRAPHS FOR THE CONFLUENCE OF N. AND S. WALNUT CREEKS (PONDS A-4 AND B-5 FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 38

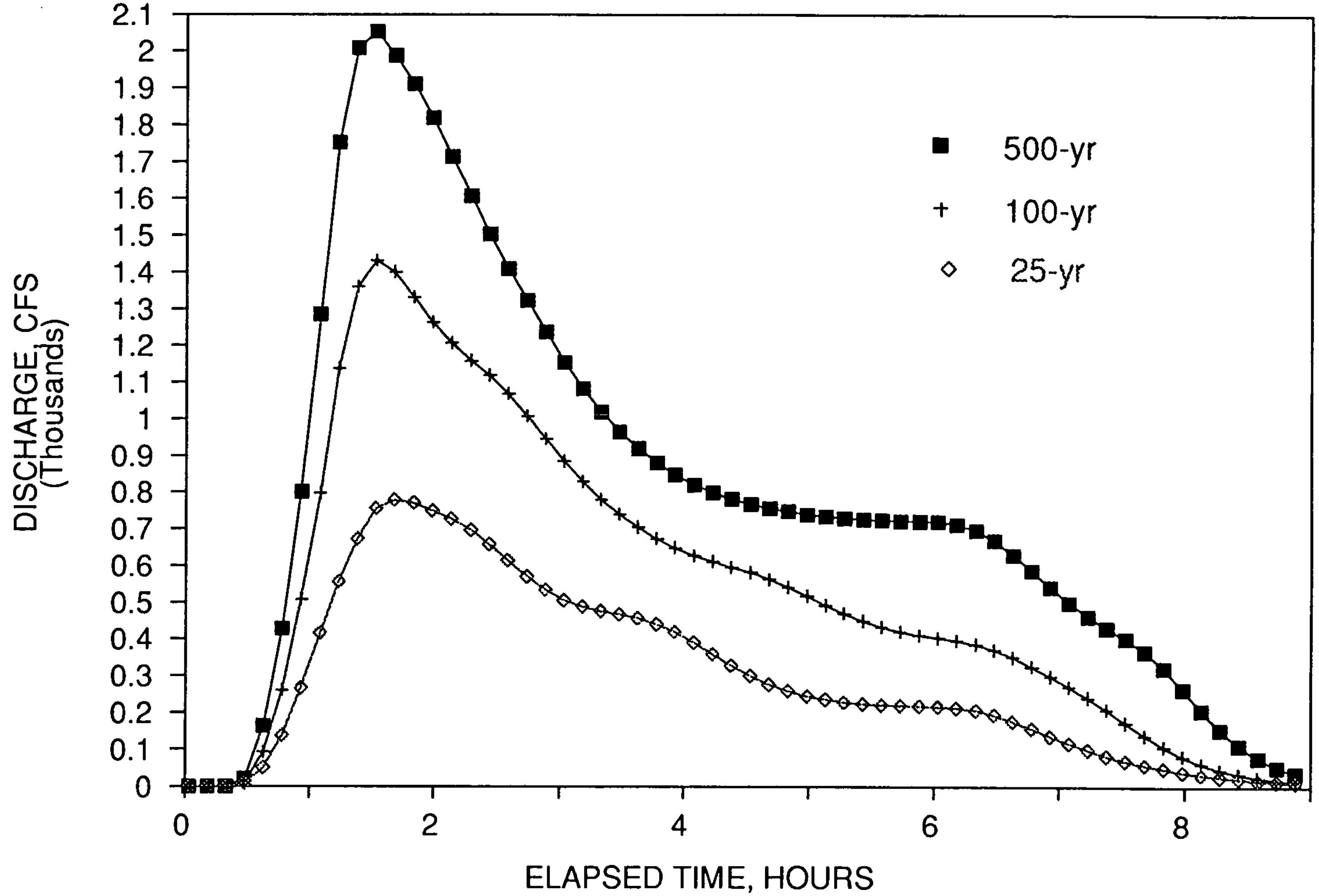


ESTIMATED FLOOD HYDROGRAPHS FOR WALNUT CREEK AT INDIANA STREET (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 39

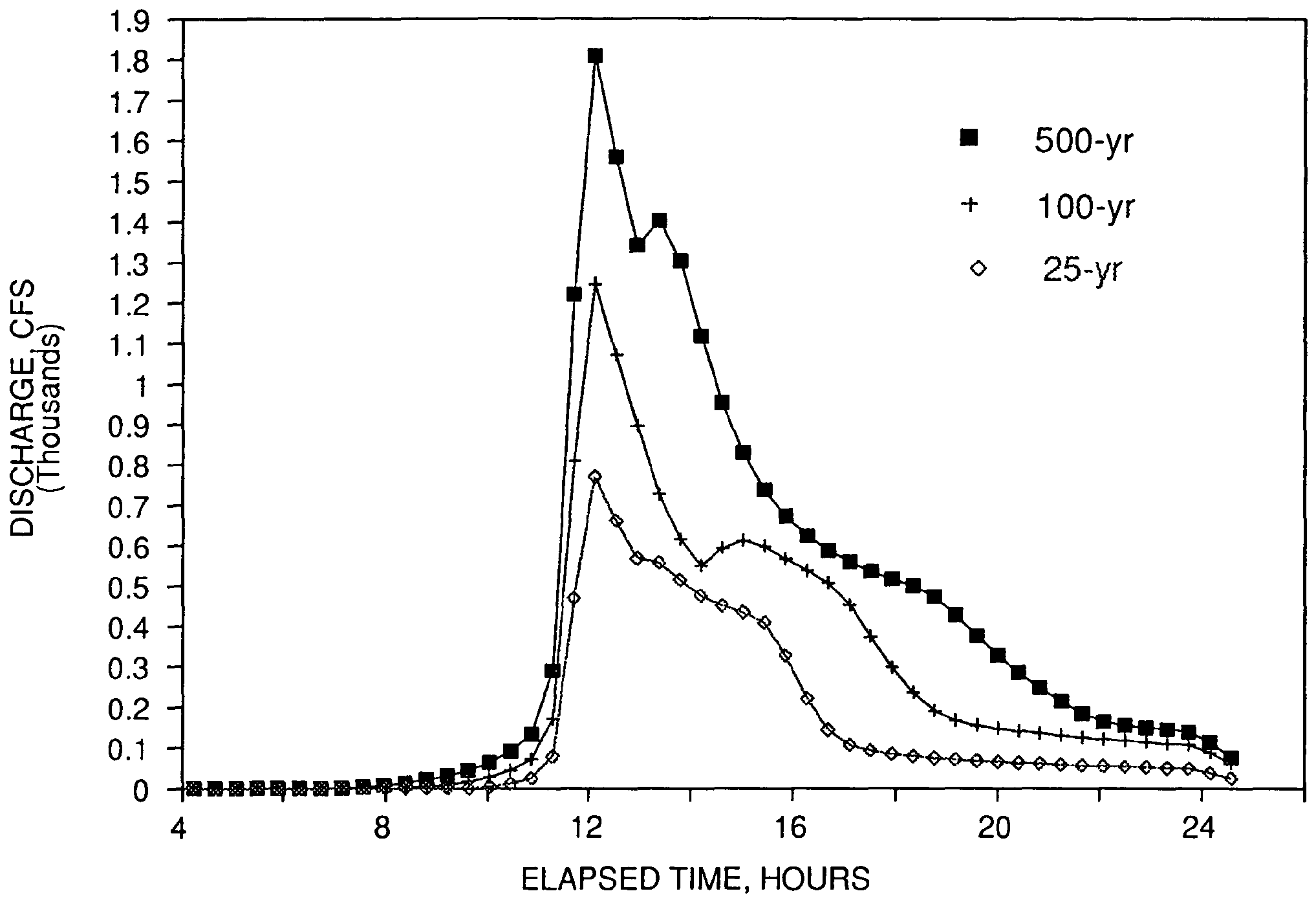


ESTIMATED FLOOD HYDROGRAPHS FOR WALNUT CREEK AT INDIANA STREET (PONDS A-4 AND B-5 FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 40

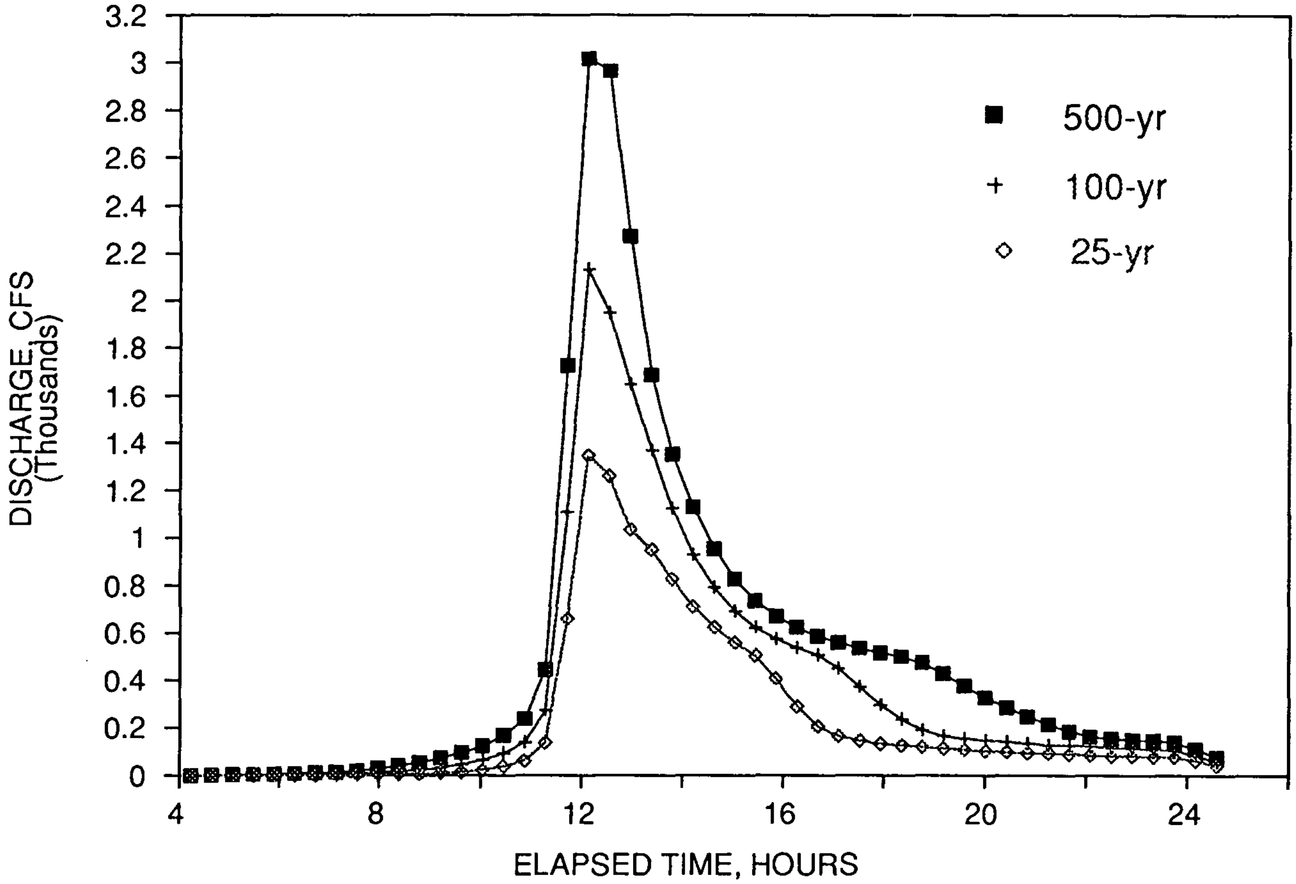


ESTIMATED FLOOD HYDROGRAPHS FOR WALNUT CREEK AT INDIANA STREET (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 41

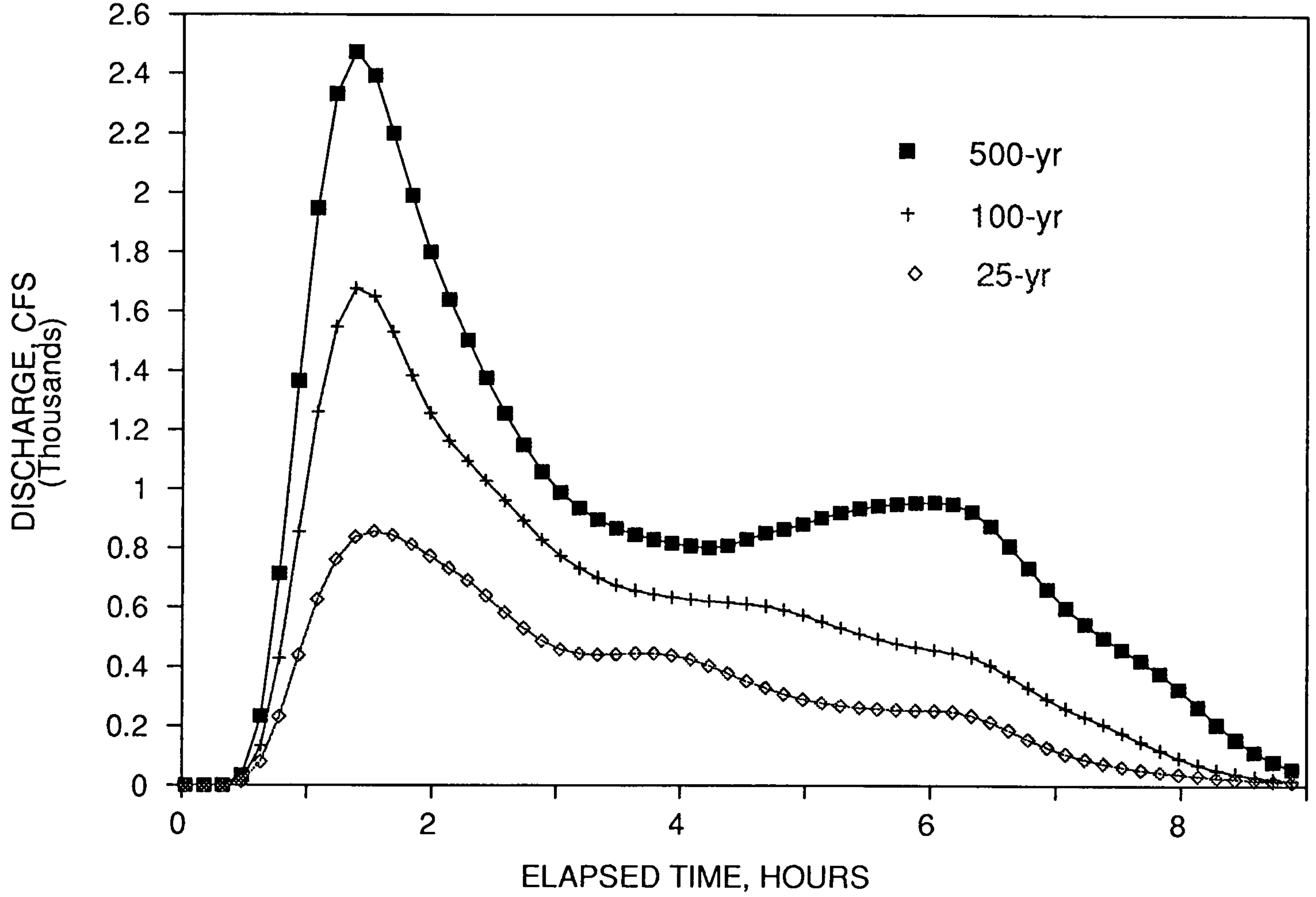


ESTIMATED FLOOD HYDROGRAPHS FOR WALNUT CREEK AT INDIANA STREET (PONDS A-4 AND B-5 FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 42

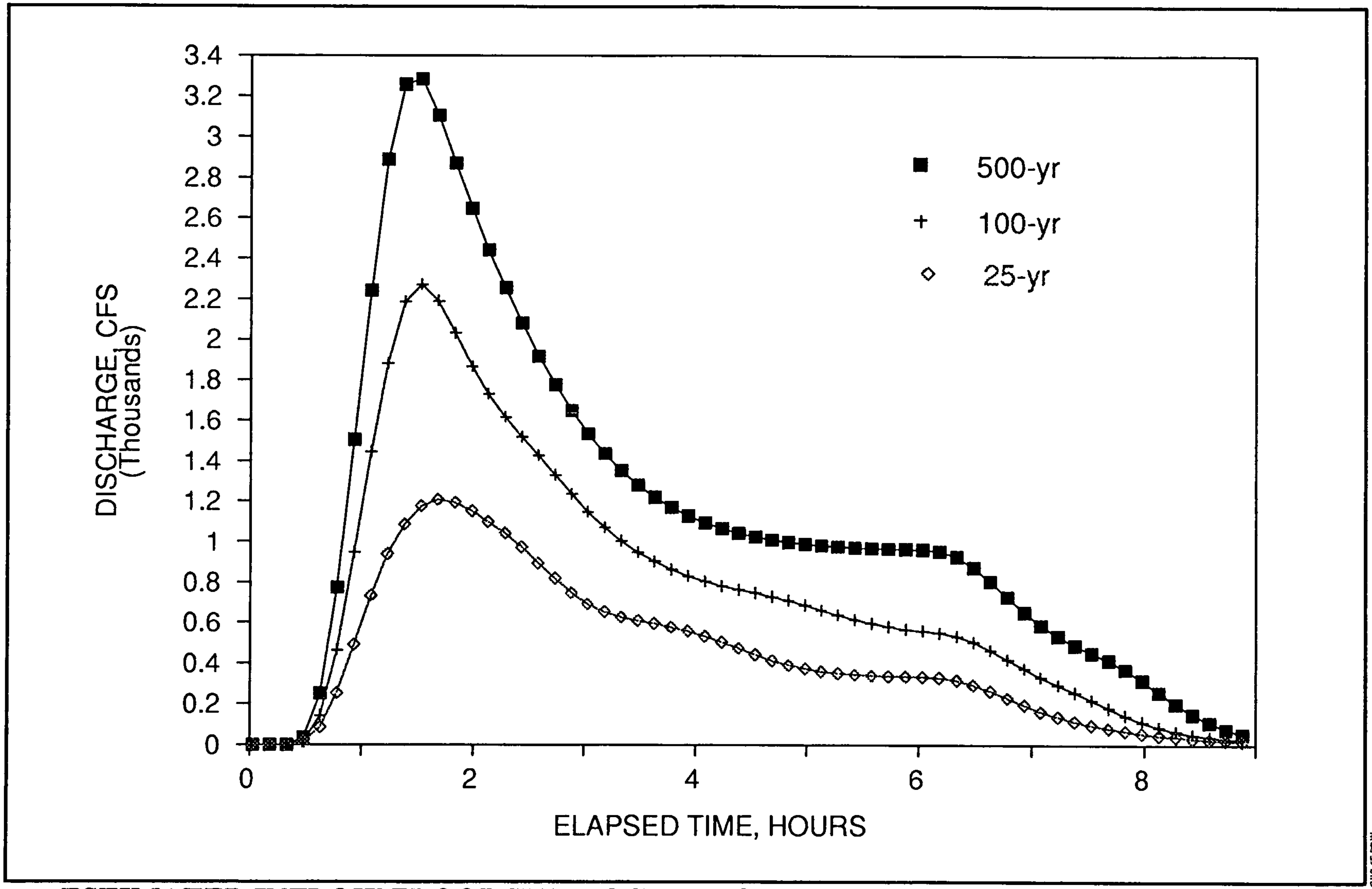


ESTIMATED INFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 43

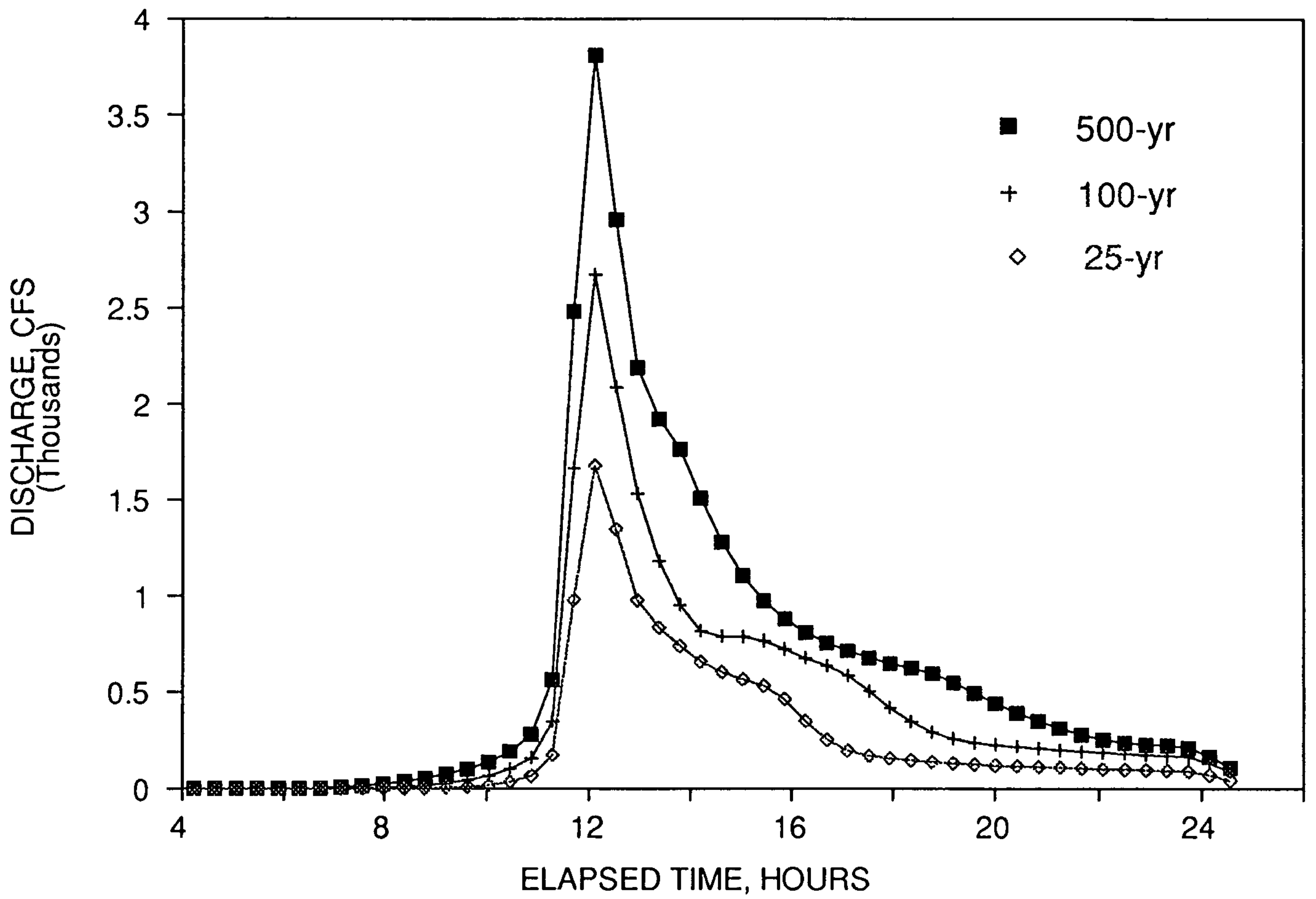


ESTIMATED INFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (PONDS A-4 AND B-5 FULL AT BEGINNING OF 6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 44

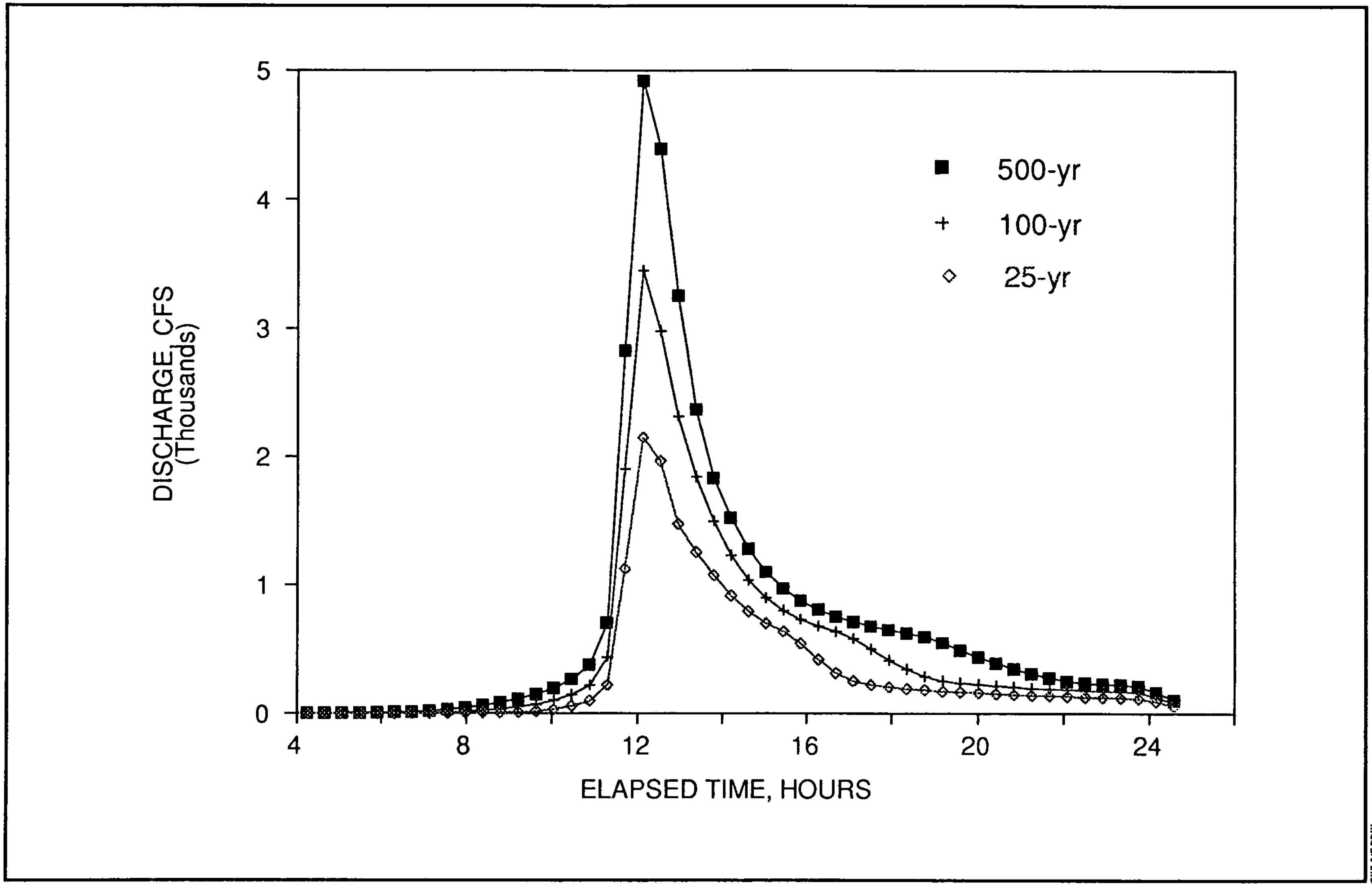


ESTIMATED INFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (PONDS A-4 AND B-5 EMPTY AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 45

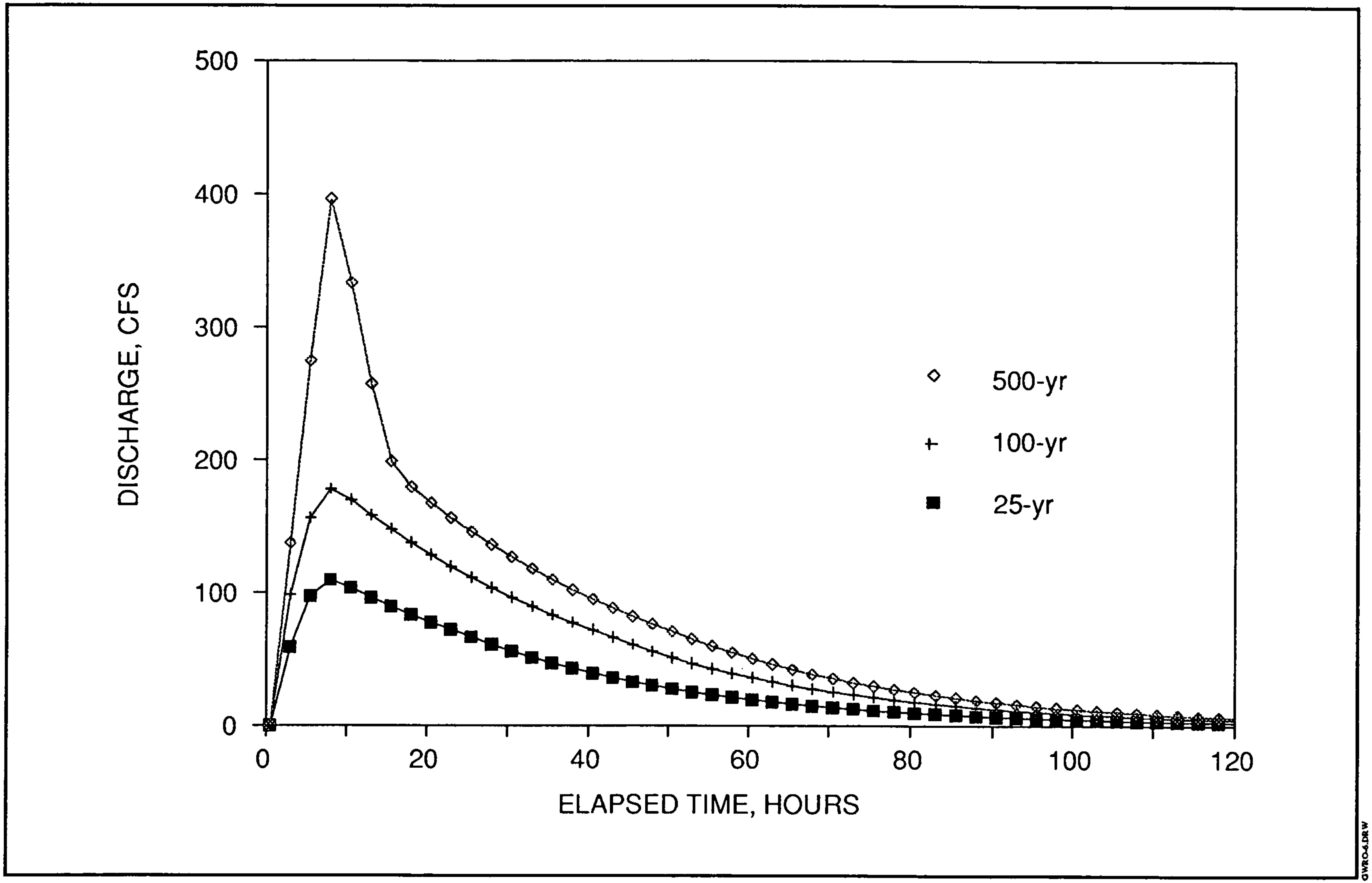


ESTIMATED INFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (PONDS A-4 AND B-5 FULL AT BEGINNING OF 24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 46

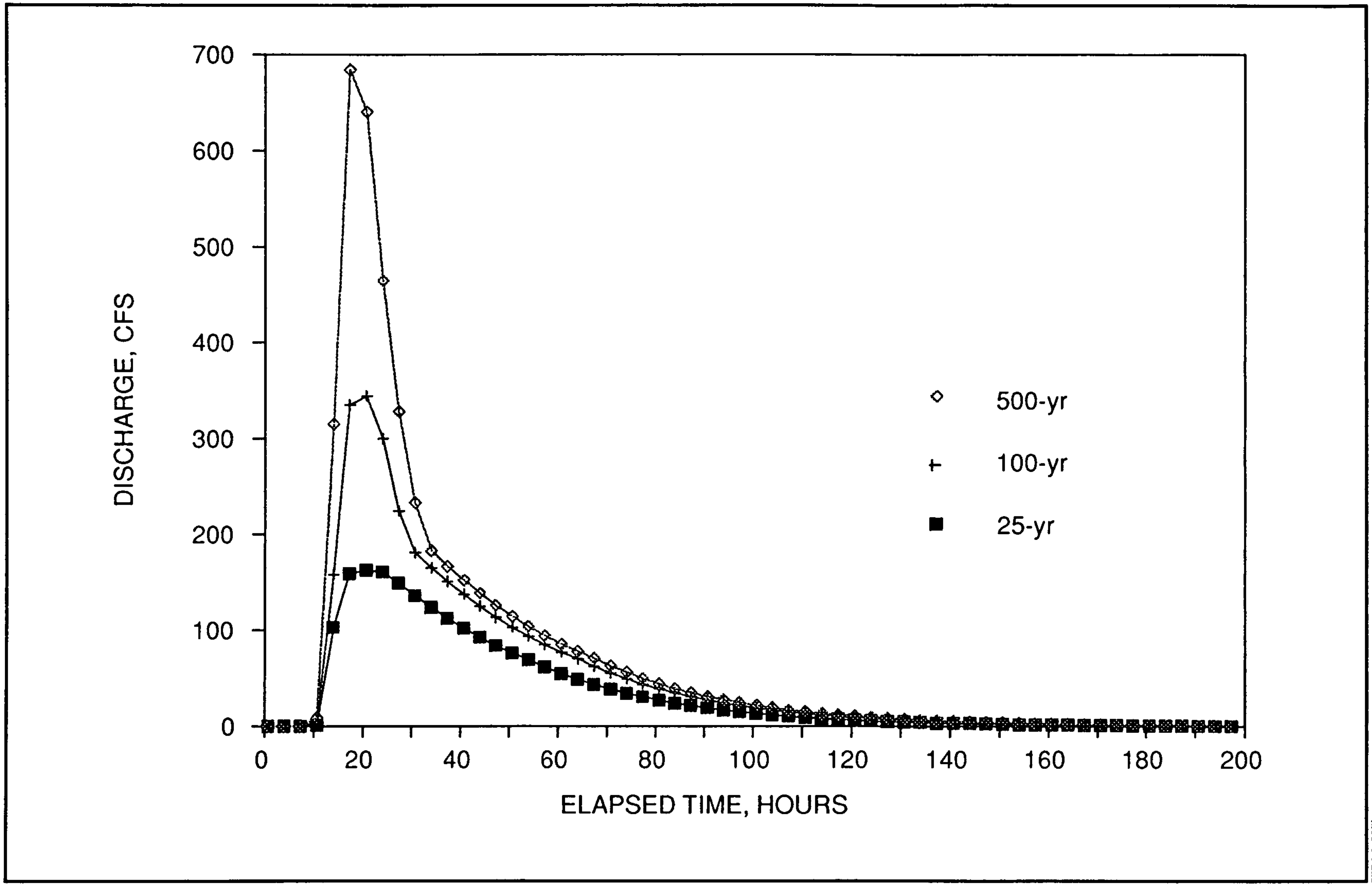


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (6-HR DURATION)
(GREAT WESTER RESERVOIR, POND A-4 AND POND B-5 EMPTY AT BEGINNING OF STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 47

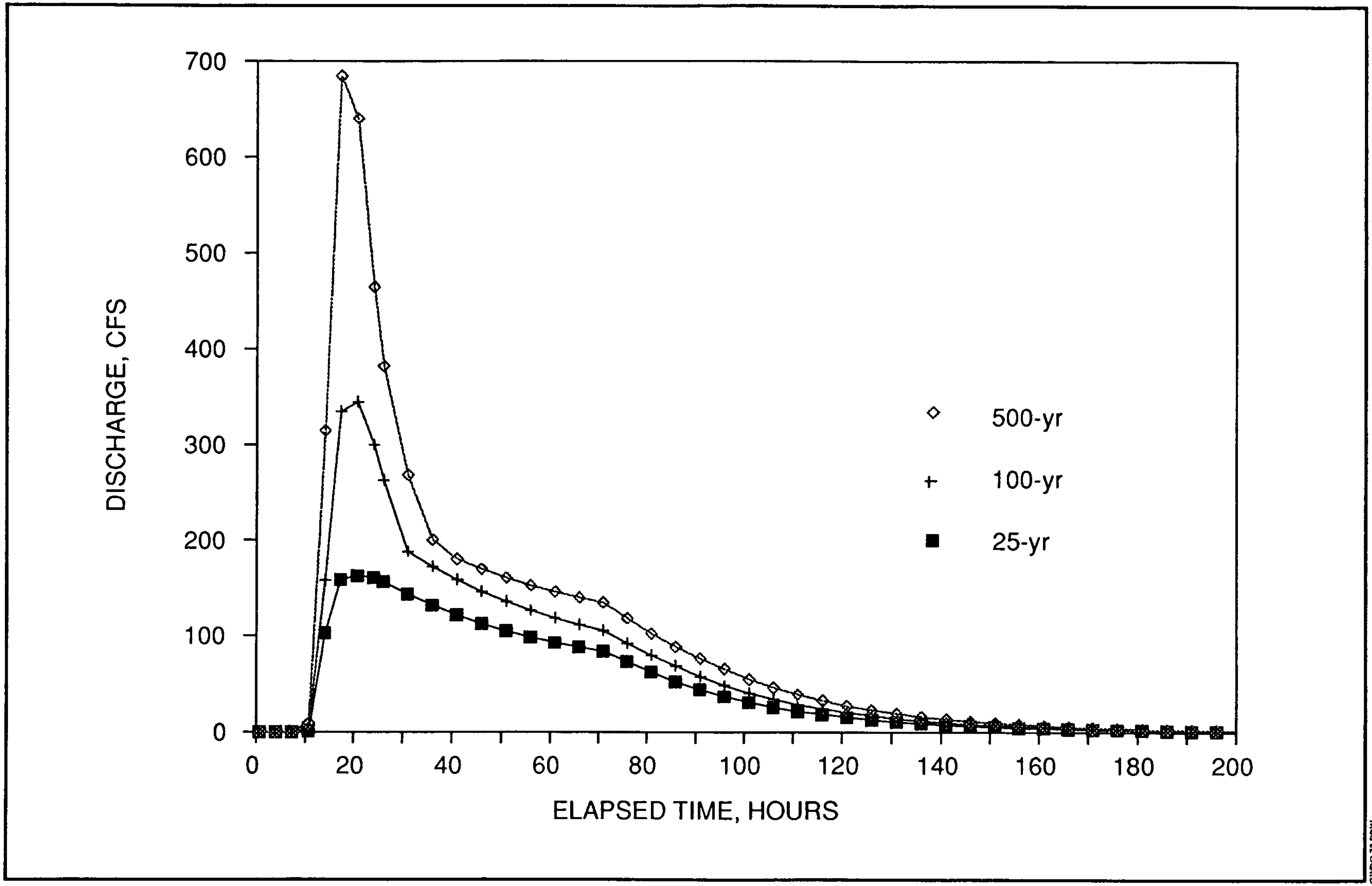


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR (24-HR DURATION)
(GREAT WESTERN RESERVOIR, POND A-4 AND POND B-5 FULL AT BEGINNING OF STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 48

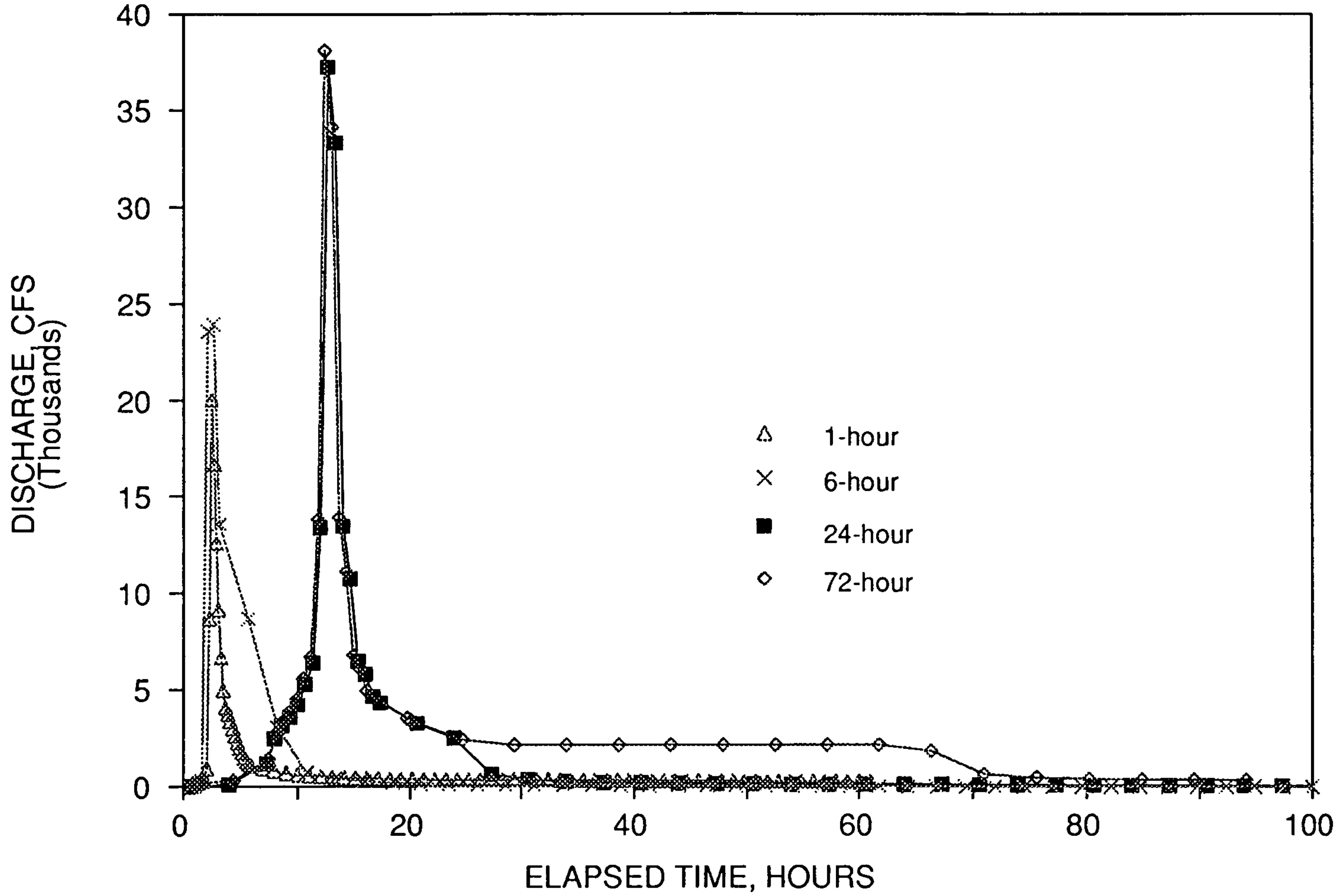


ESTIMATED OUTFLOW FLOOD HYDROGRAPHS FORGREAT WESTERN RESERVOIR (72-HR DURATION)
(GREAT WESTERN RESERVOIR, POND A-4 AND POND B-5 FULL AT BEGINNING OF STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 49

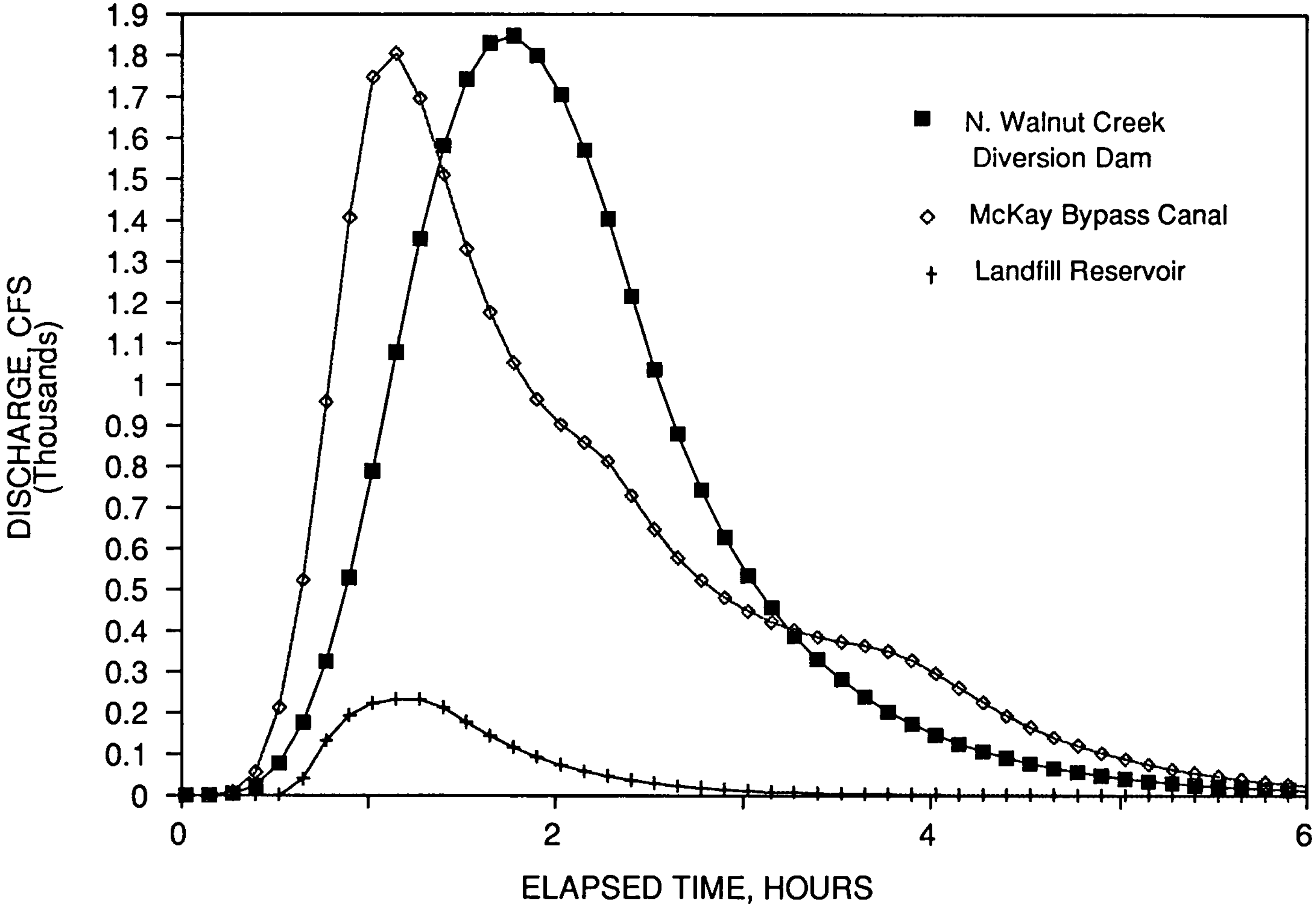


ESTIMATED PMP OUTFLOW FLOOD HYDROGRAPHS FOR GREAT WESTERN RESERVOIR
(GREAT WESTERN RESERVOIR, POND A-4 AND POND B-5 FULL AT BEGINNING OF STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 50

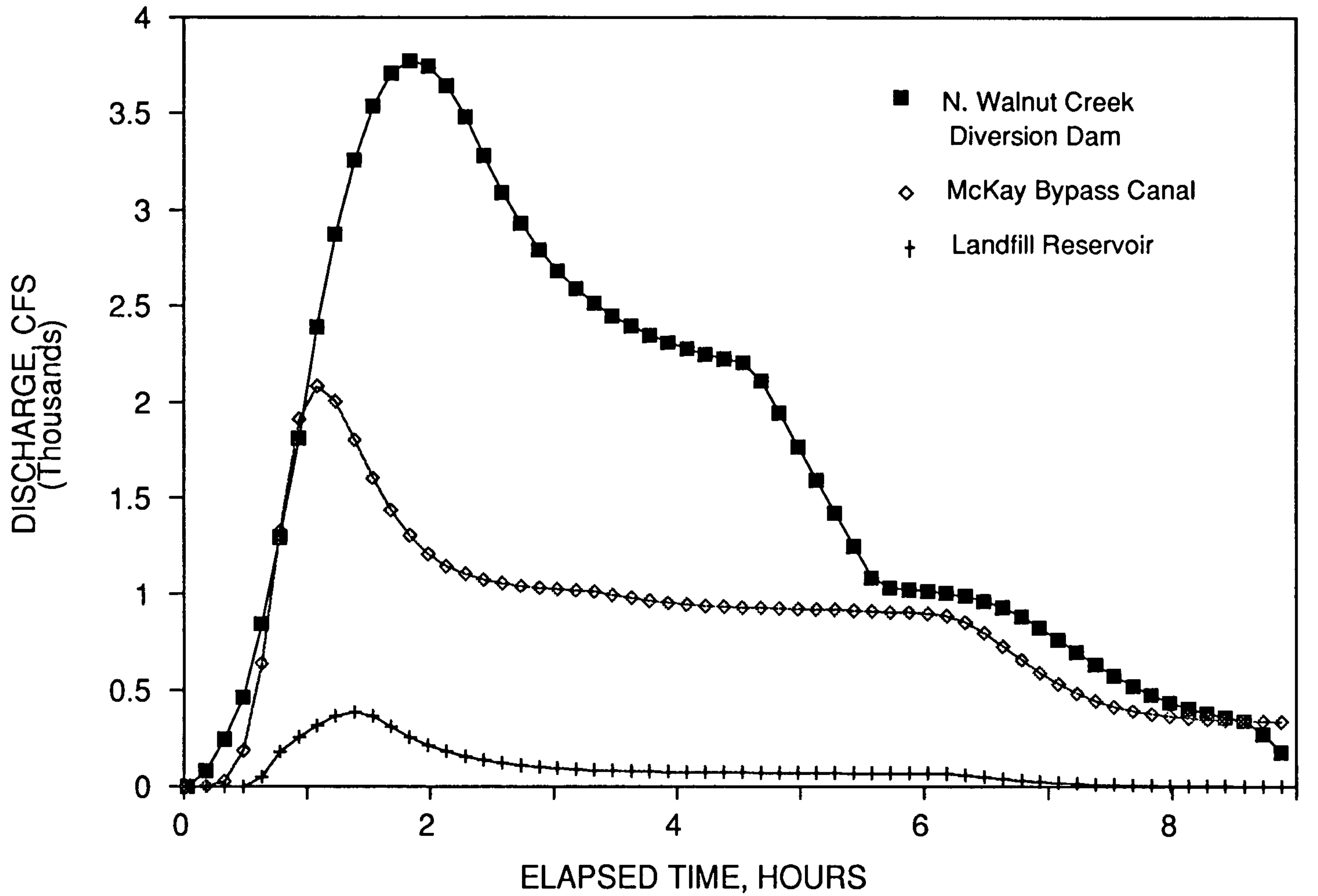


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED IN THE NORTH WALNUT CREEK WATERSHED (1-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 51

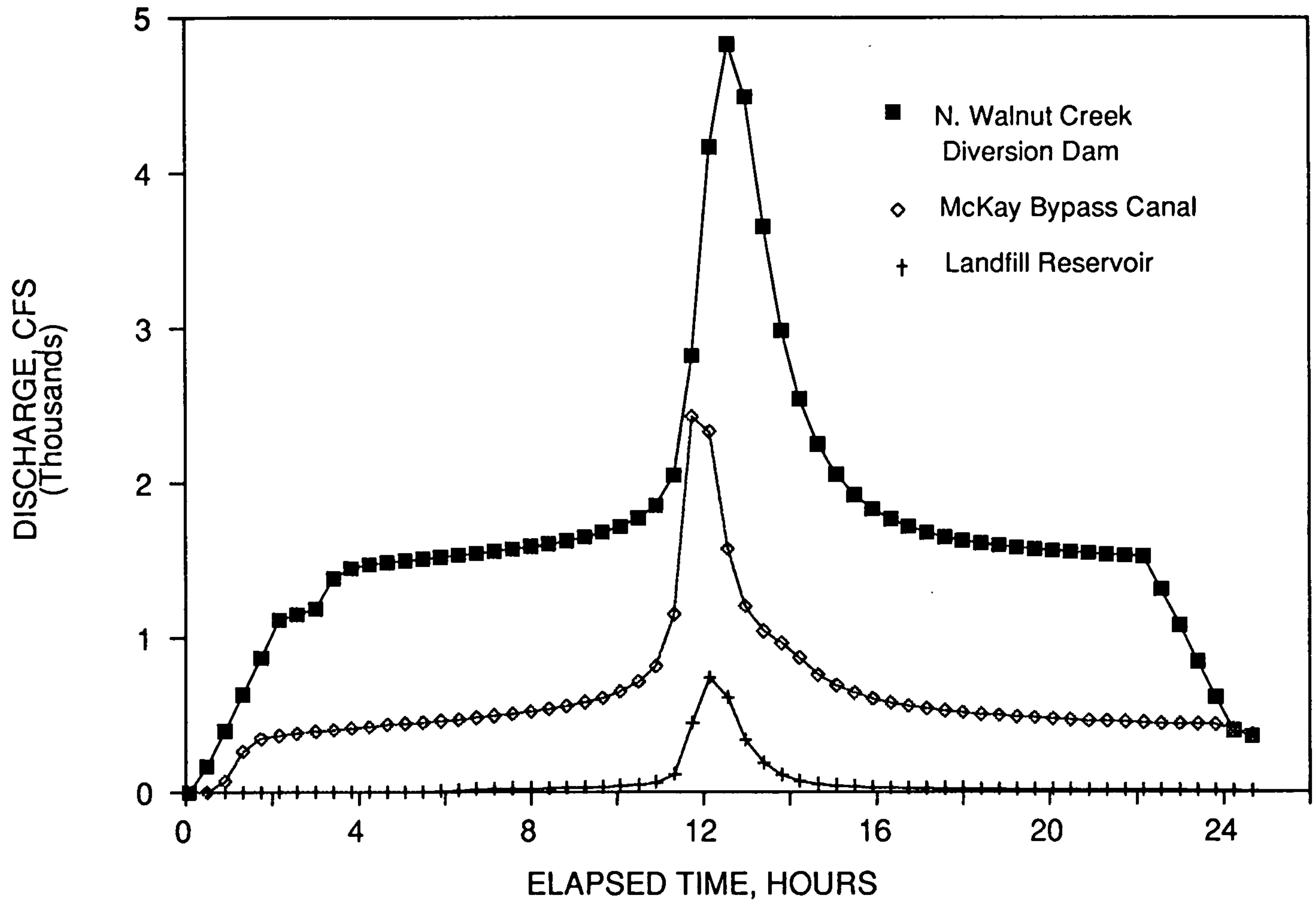


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED IN THE NORTH WALNUT CREEK WATERSHED (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 52

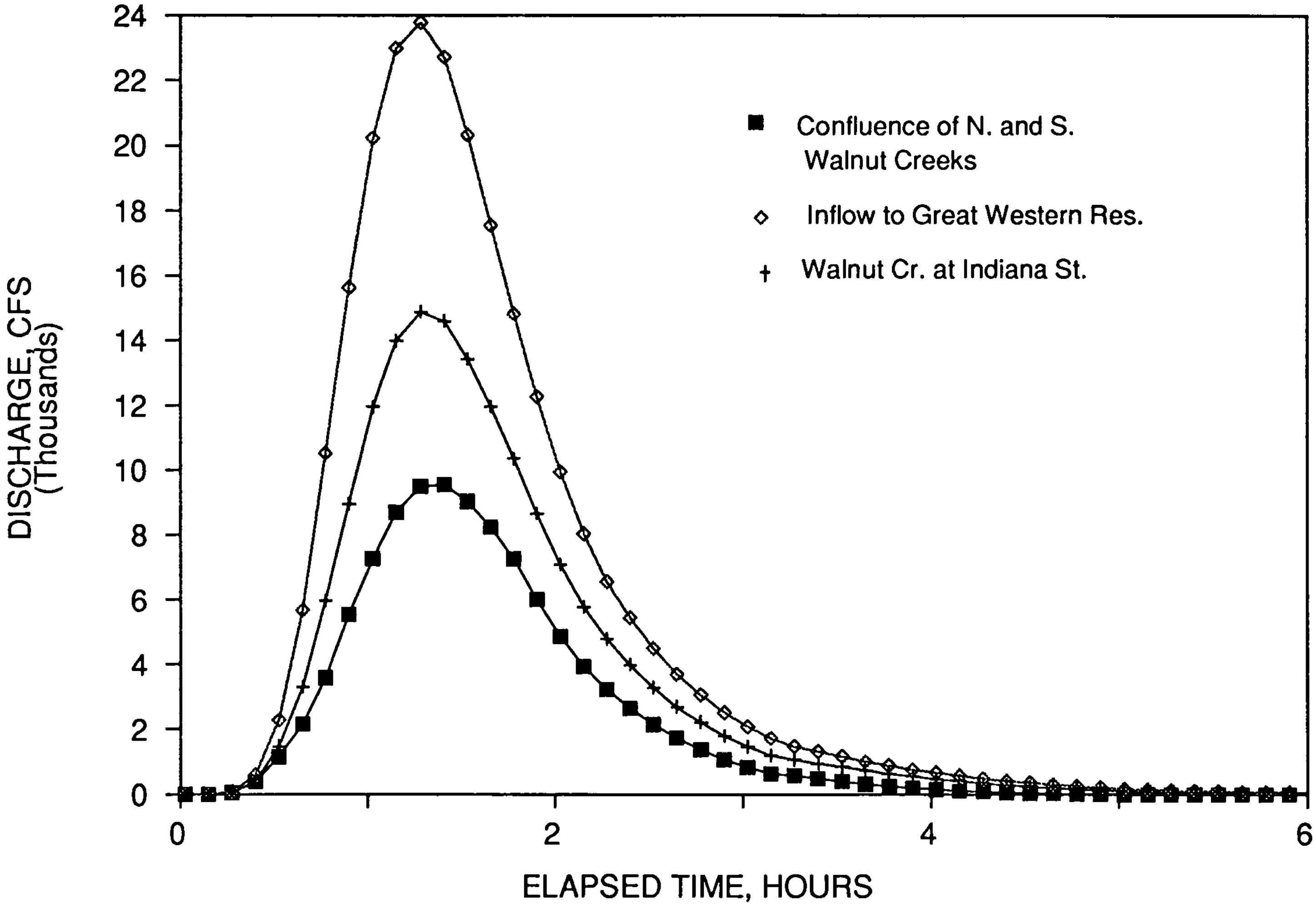


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED IN THE NORTH WALNUT CREEK WATERSHED (24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 53

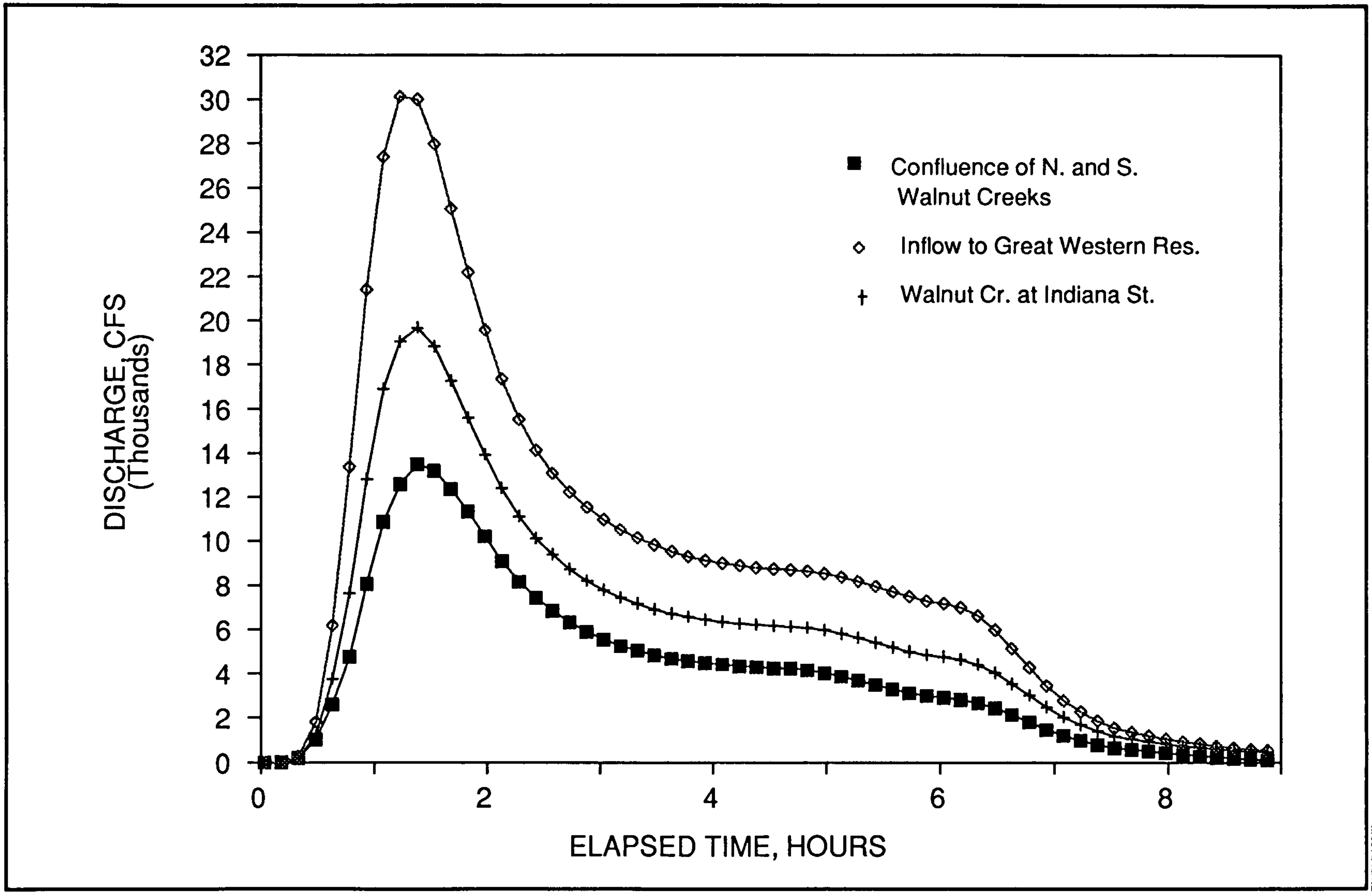


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED SITES IN THE WALNUT CREEK WATERSHED (1-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 54

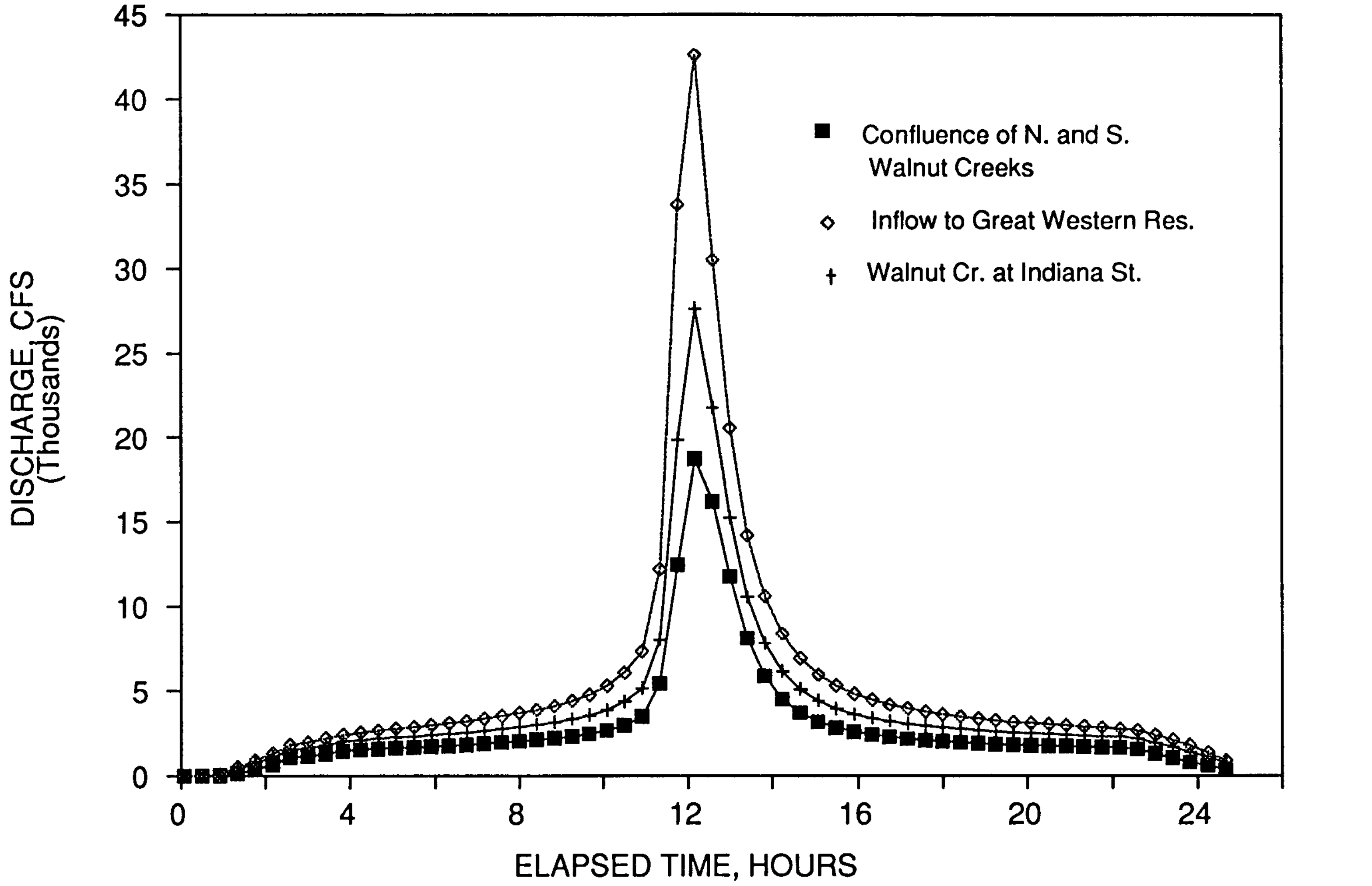


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED SITES IN THE WALNUT CREEK WATERSHED (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 55

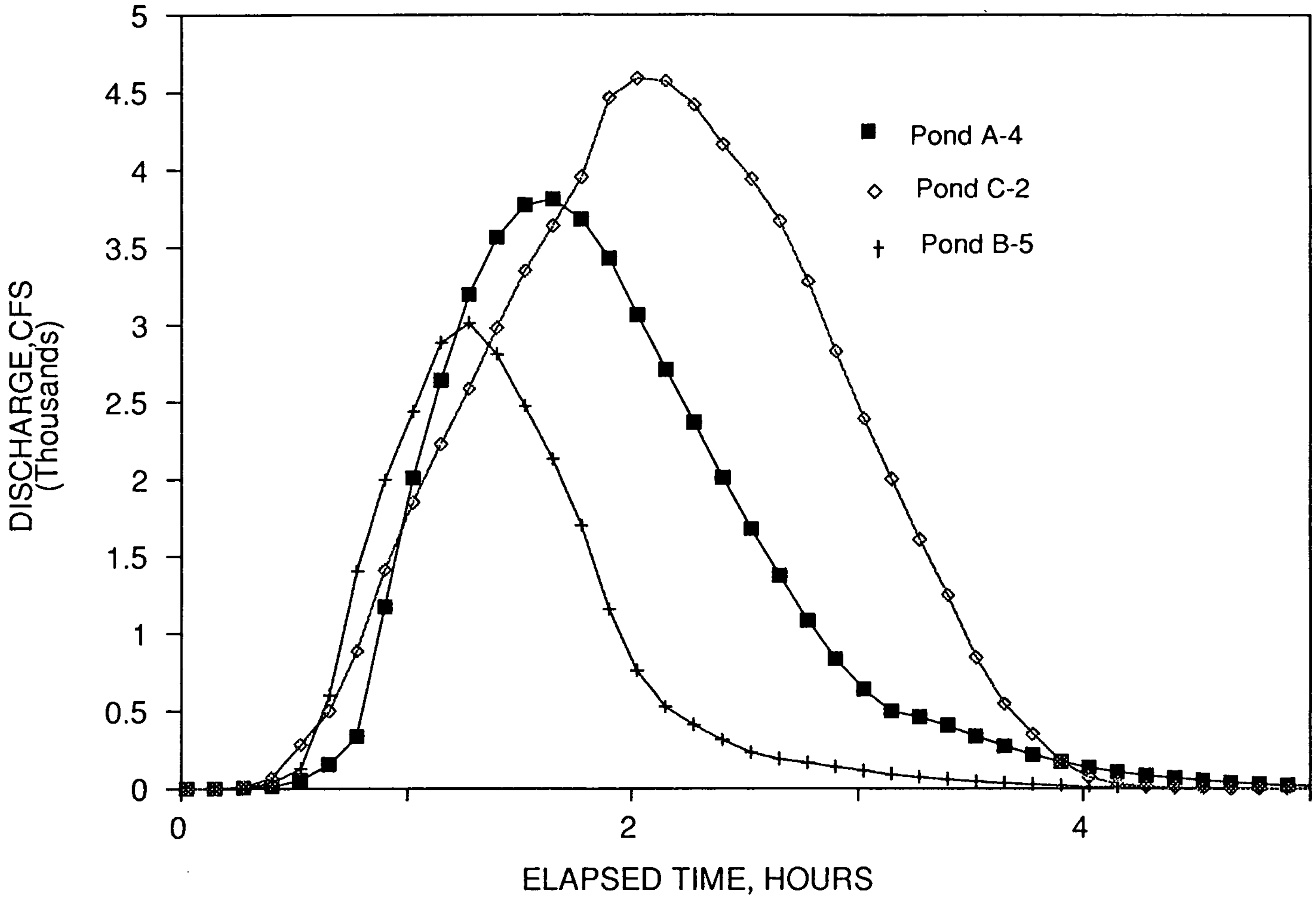


ESTIMATED PMP FLOOD HYDROGRAPHS FOR SELECTED SITES IN THE WALNUT CREEK WATERSHED (24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 56

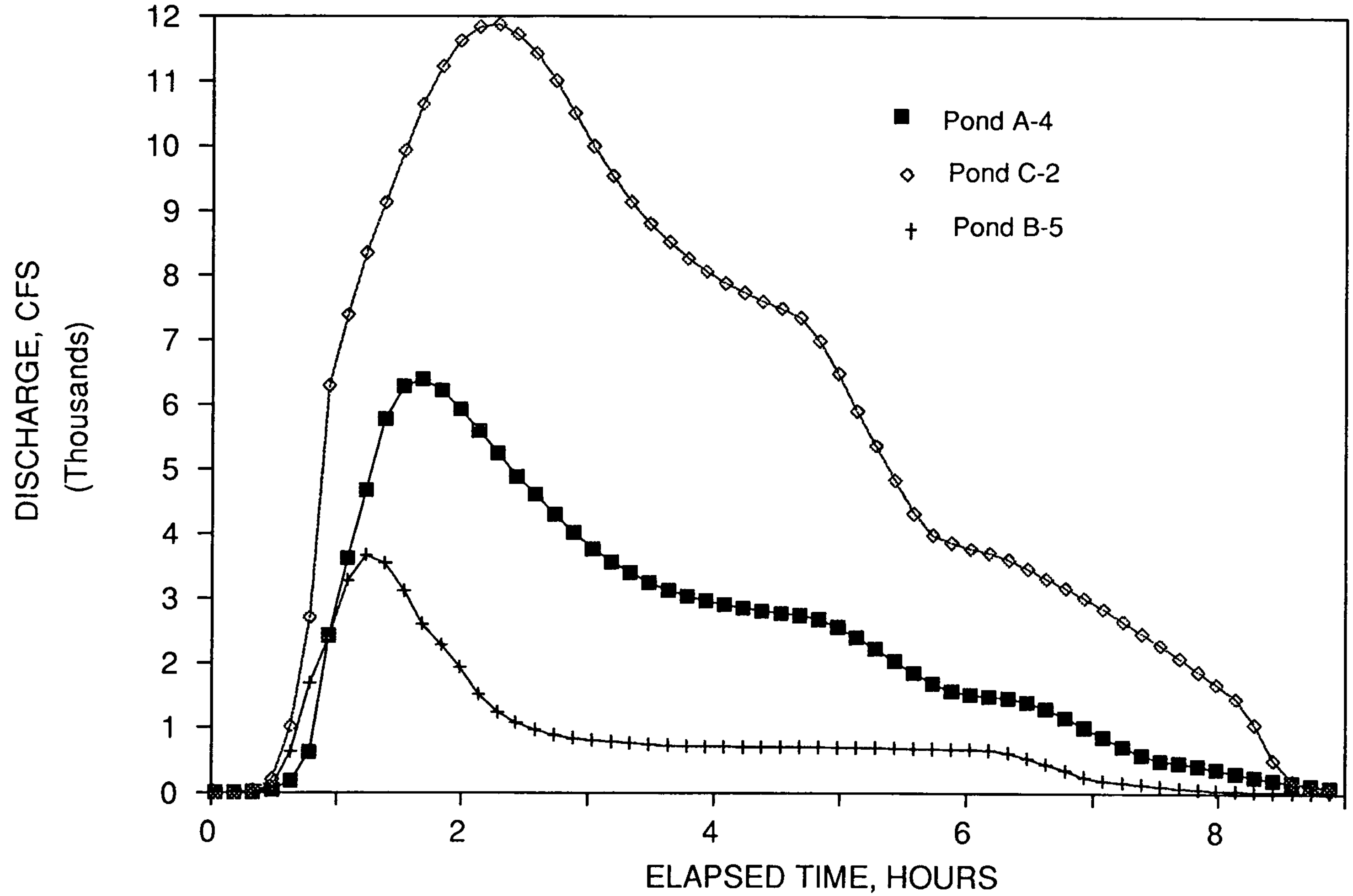


ESTIMATED PMP OUTFLOW FLOOD HYDROGRAPHS FOR RFP PONDS
(1-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 57

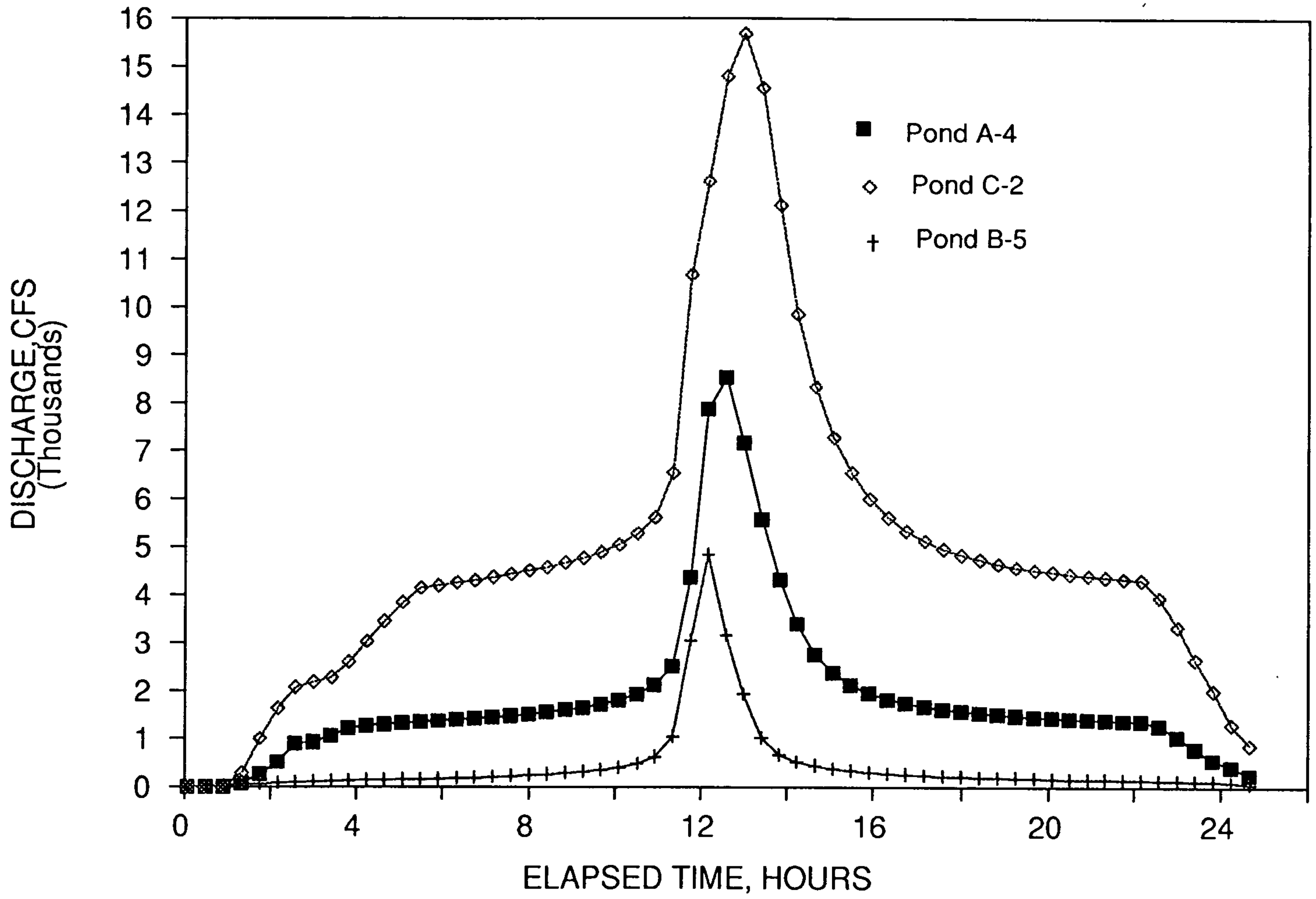


ESTIMATED PMP OUTFLOW FLOOD HYDROGRAPHS FOR RFP PONDS (6-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 58

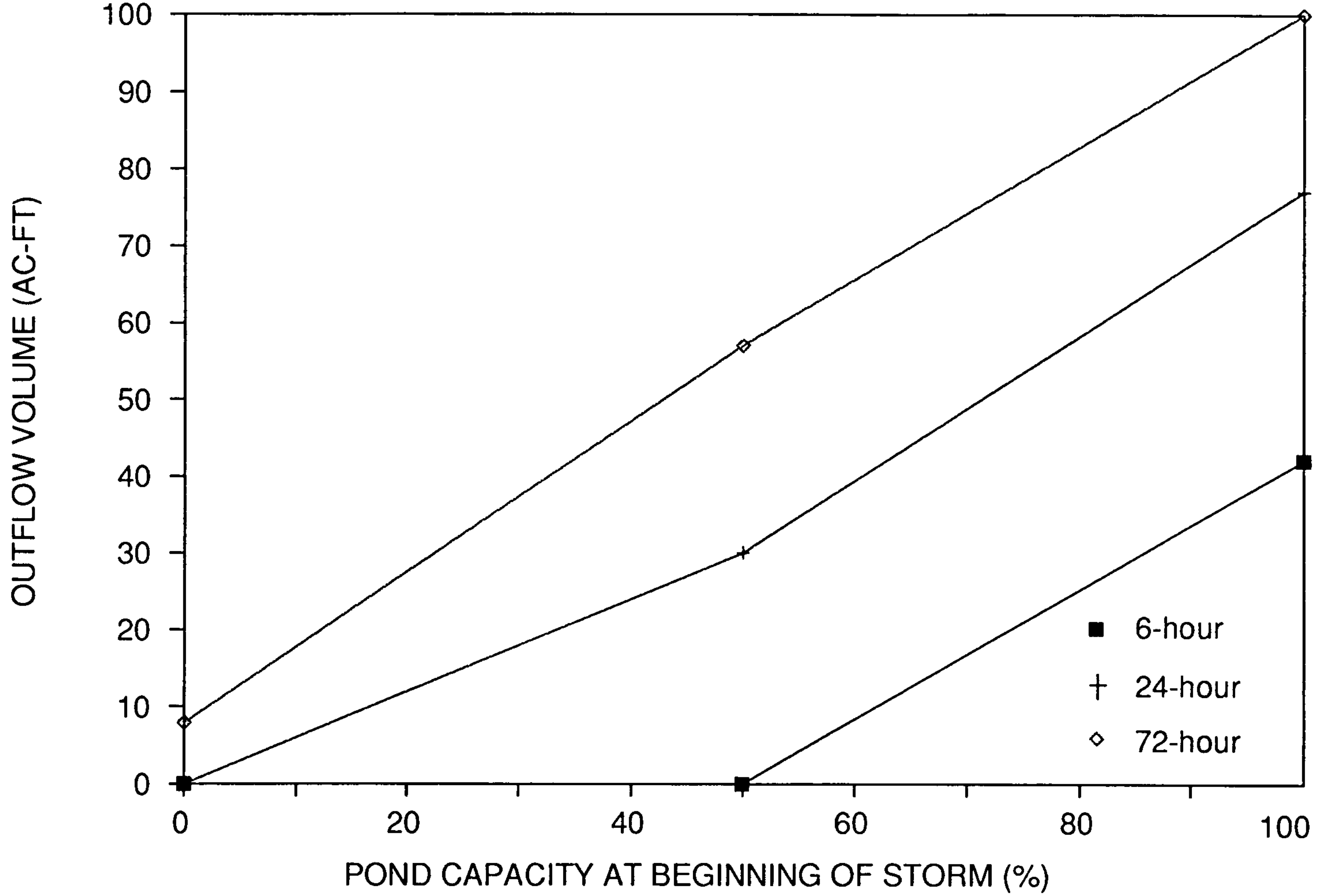


ESTIMATED PMP OUTFLOW FLOOD HYDROGRAPHS FOR RFP PONDS
(24-HOUR DURATION STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 59

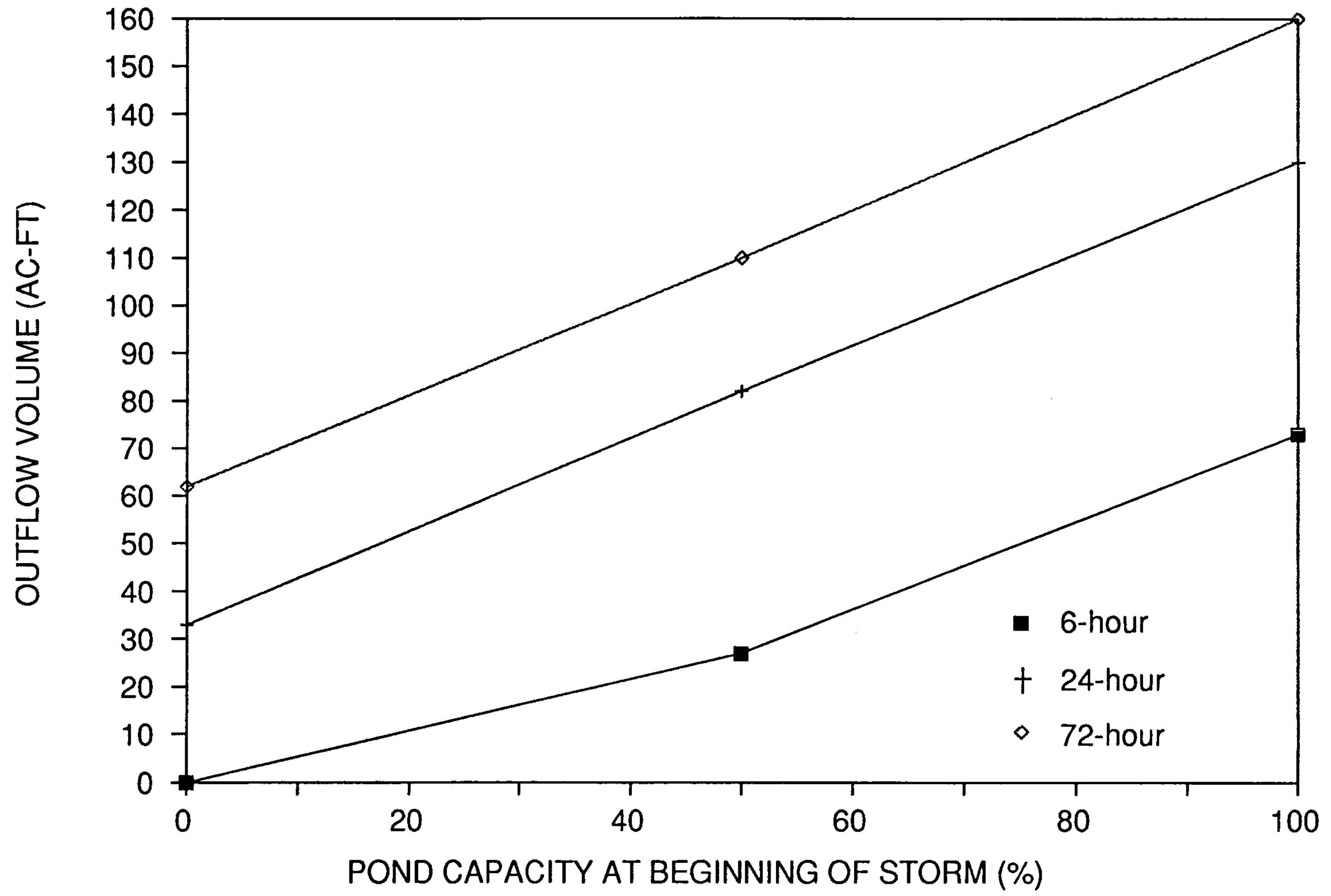


ESTIMATED POND A-4 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (25-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 60

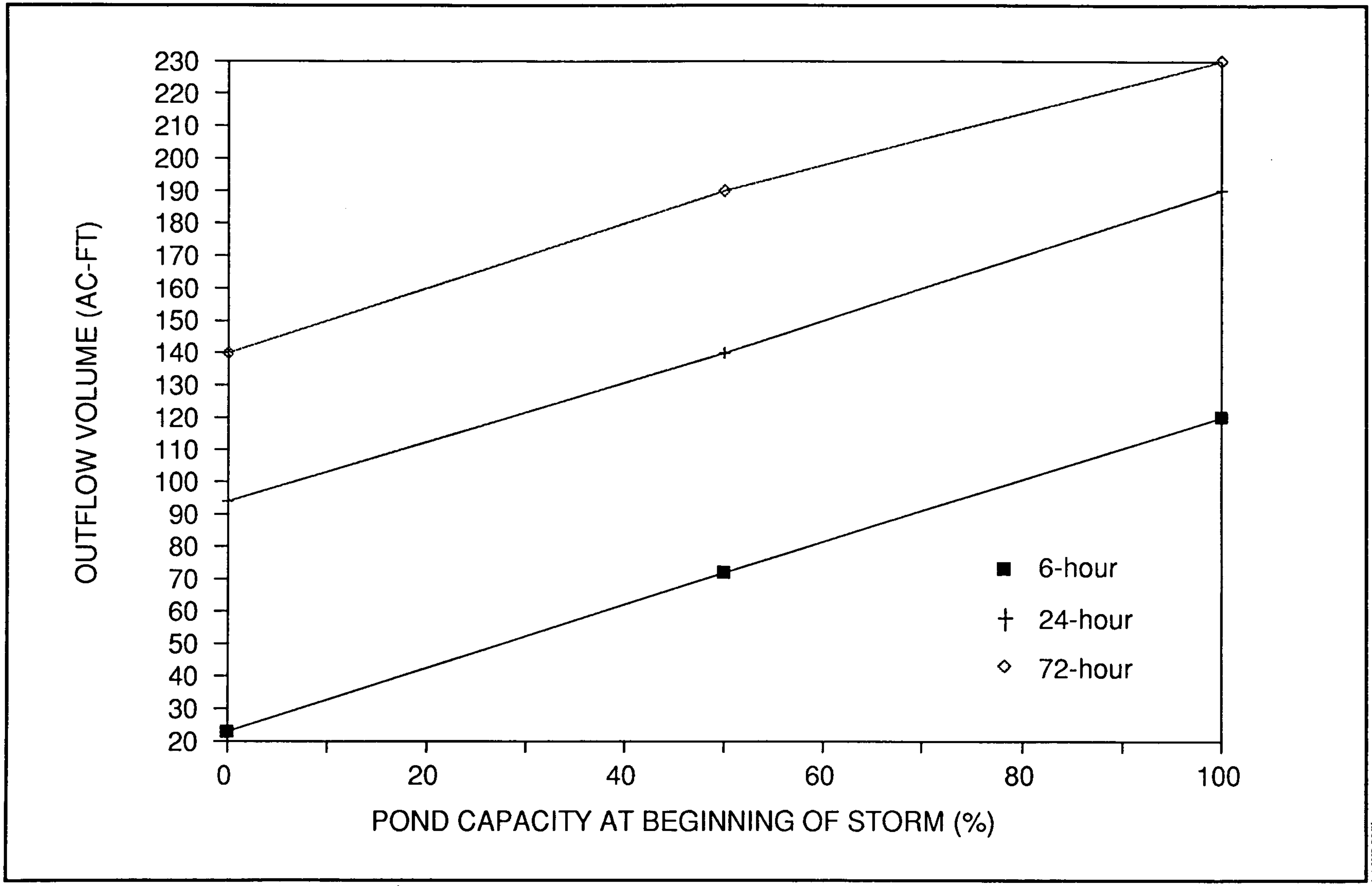


ESTIMATED POND A-4 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (100-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 61

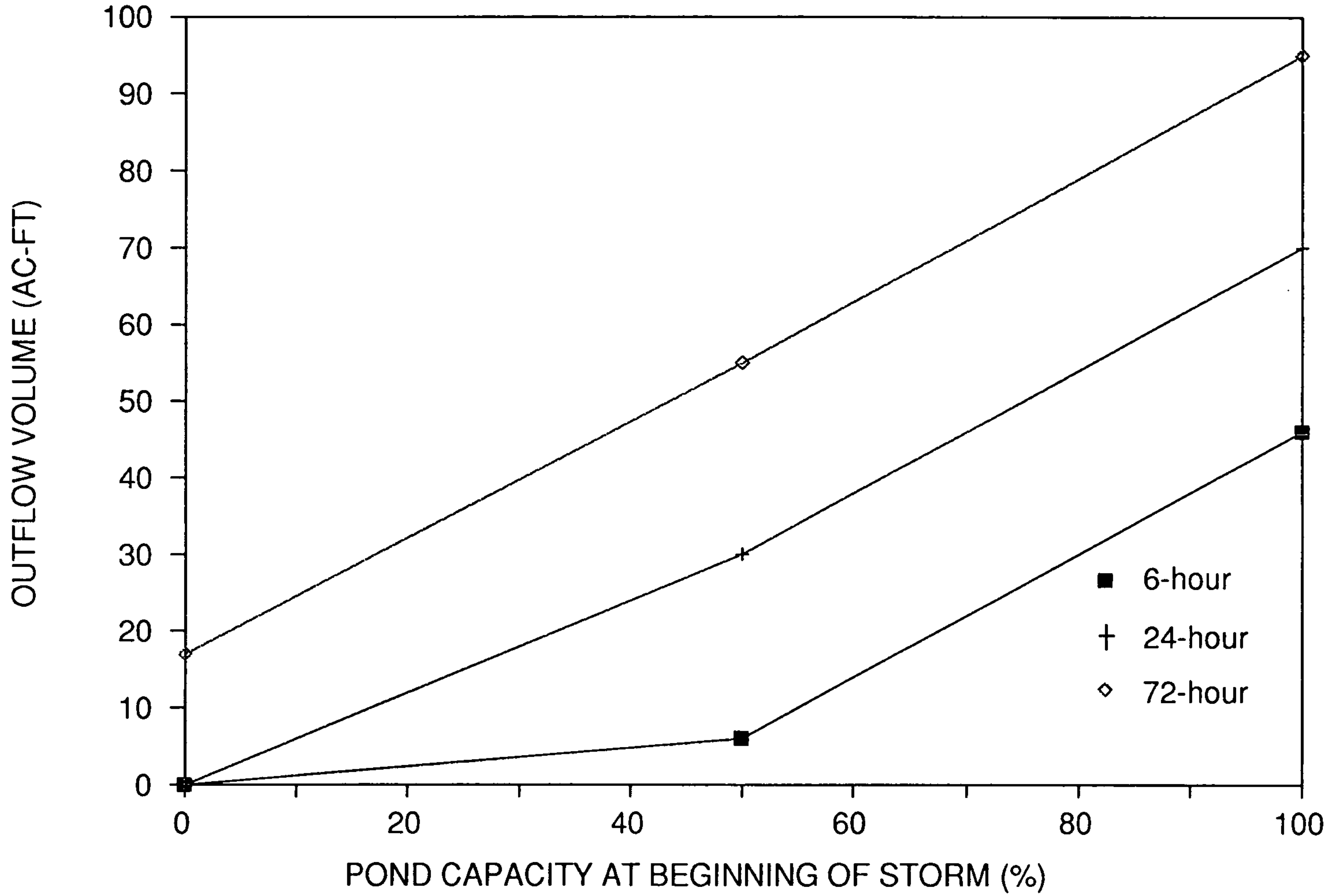


ESTIMATED POND A-4 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (500-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 62

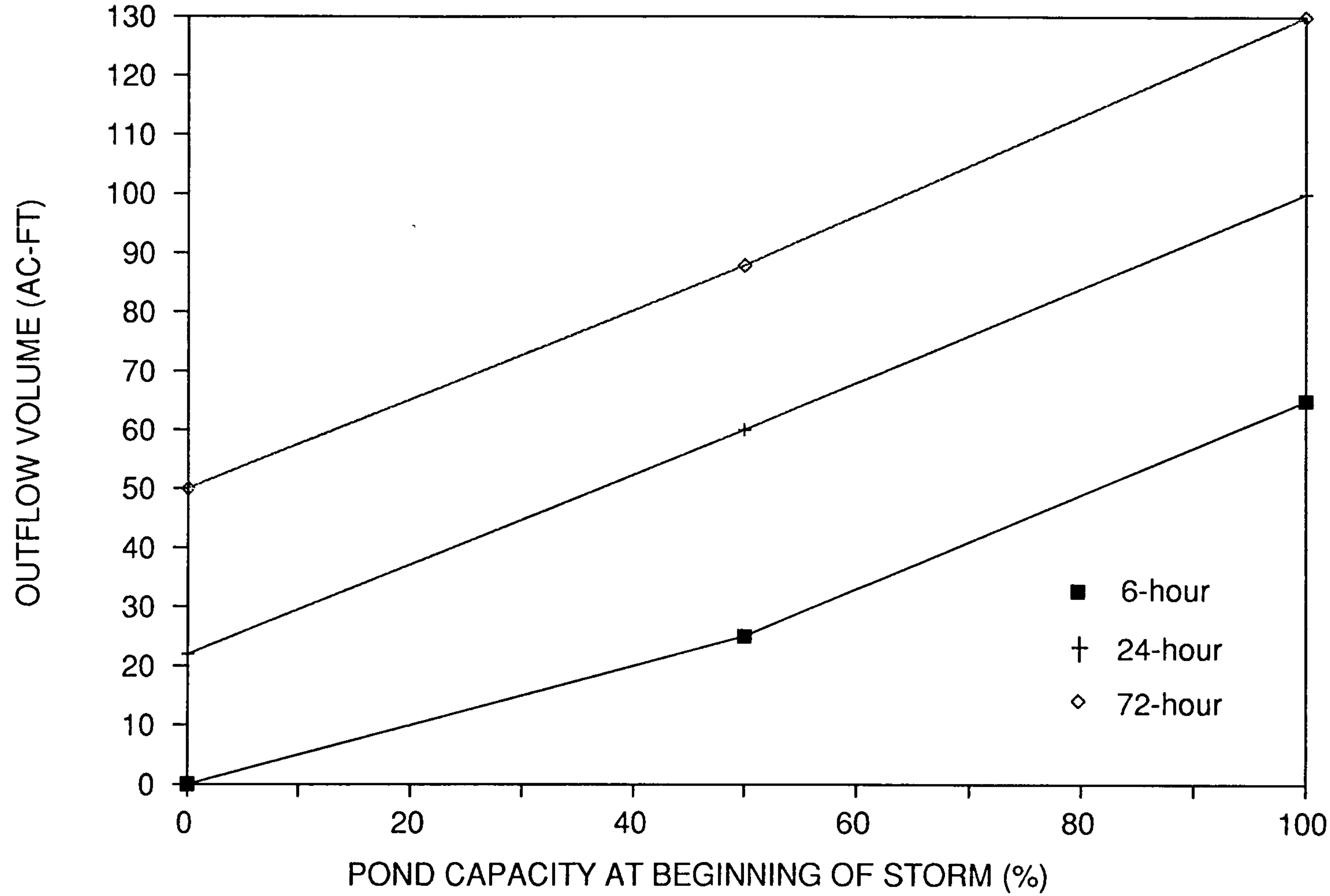


ESTIMATED POND B-5 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (25-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 63

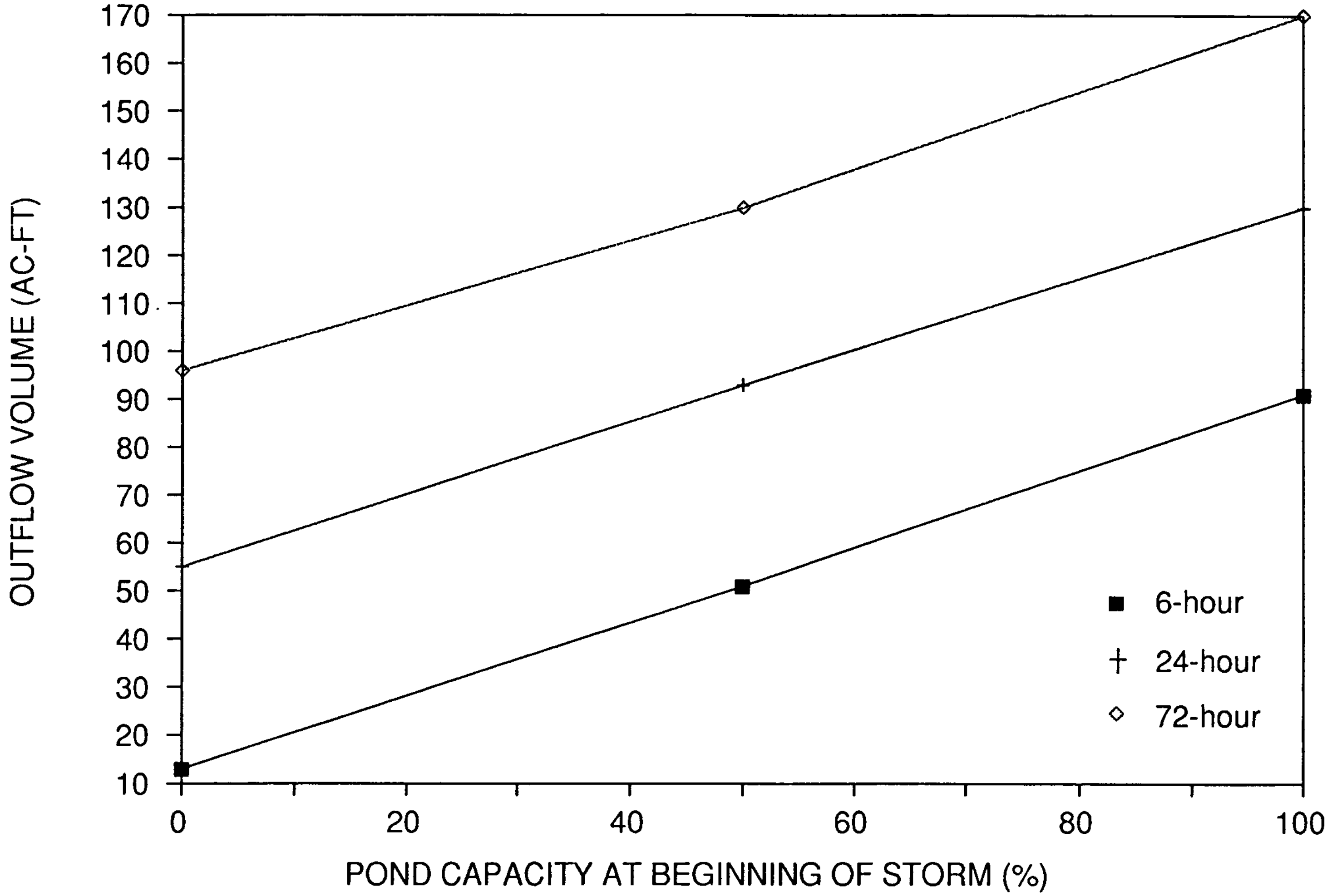


ESTIMATED POND B-5 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (100-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 64

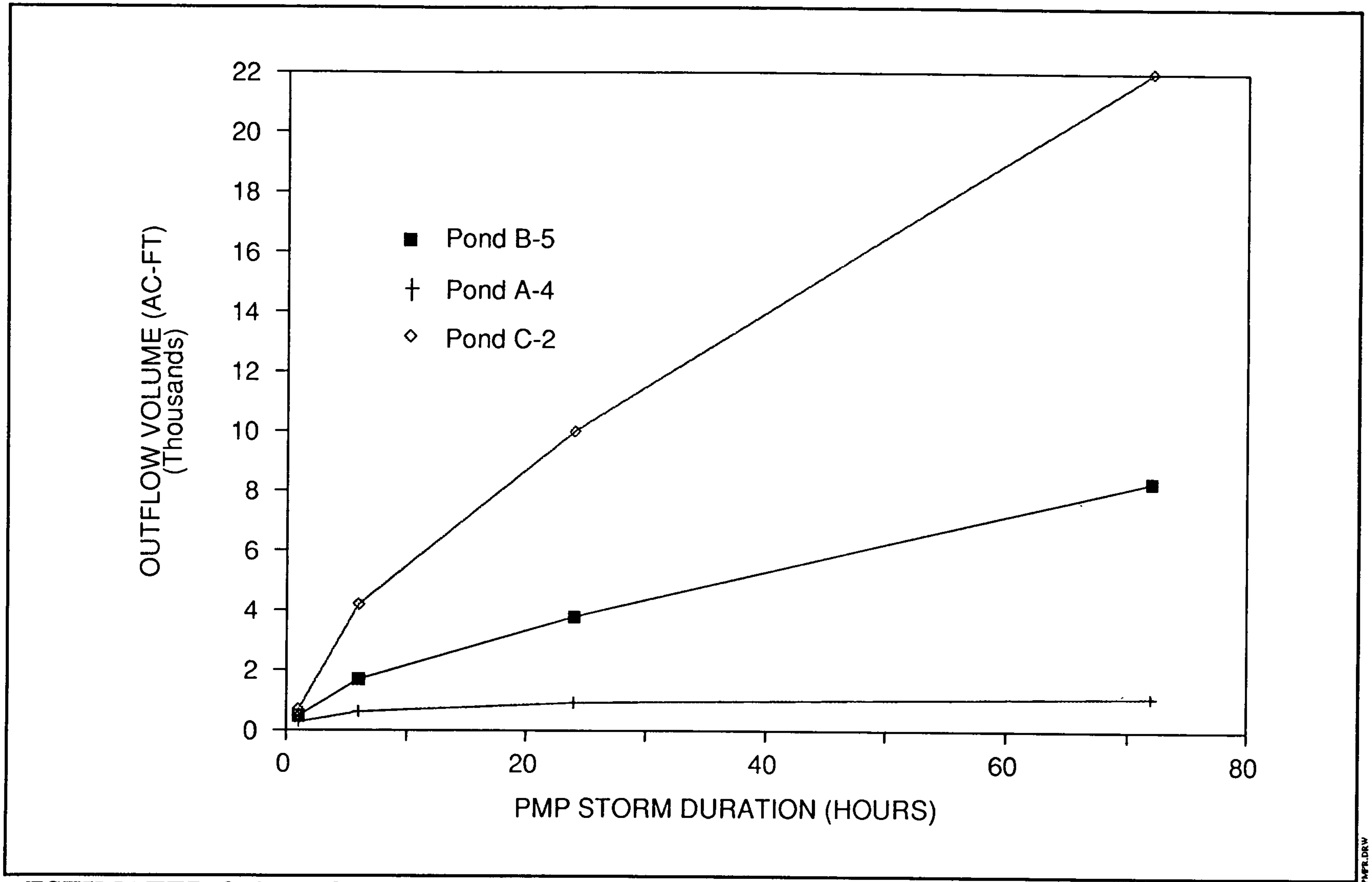


ESTIMATED POND B-5 OUTFLOW RUNOFF VOLUME vs. POND CAPACITY AT THE BEGINNING OF A STORM RUNOFF EVENT (500-YEAR STORM)

STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 65



ESTIMATED OUTFLOW RUNOFF VOLUME vs. PMP STORM DURATION FOR RFP PONDS (PONDS ASSUMED TO BE FULL AT BEGINNING OF STORM)

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. 66

A

APPENDIX A

DEFINITIONS

Antecedent Moisture Condition (AMC): The amount of precipitation occurring 5 days preceeding the storm being analyzed determines the antecedent moisture condition (AMC). SCS presumes a dry condition, or AMC I, if less than 1.4 in. of precipitation, during the growing season, and less than 0.5 in., during the dormant season, have fallen in the 5 preceding days. A wet condition, or AMC III, is presumed if greater than 2.1 in. or 1.1 in. of precipitation, respectively, during the growing or dormant seasons, have fallen in the preceding 5 days. Average conditions, AMC II, are presumed for preceding rainfall amounts in between.

Peak Discharge: The highest instantaneous discharge during a flood from a given drainage basin. Of interest in design of open channels, spillways and culverts. Also called peak flow or flood peak.

Probable Maximum Flood: The largest flood that can reasonably be expected to occur from a drainage basin, based upon the worst meteorological and drainage basin conditons that can occur. The PMF is not associated with a recurrence interval.

Probable Maximum Precipitation: The precipitation based upon the maximized intensity-duration values for a given storm type and variation, with respect to location, areal coverage, and duration. The worst-case meteorological conditions are assumed. The PMP is not associated with a recurrence interval.

Runoff Curve Number (CN): An index or number system developed by the SCS indicating runoff potential. CN is a function of the soil type, vegetation type and density and land use. The greater the CN, the greater the runoff potential.

Runoff Volume: The total amount of runoff from a flood from a given drainage basin. Of interest in design of reservoirs. Also called storm runoff.

Storm Duration: The time that rainfall occurs over a drainage basin. Common durations used in design range from the 1-hour for small drainage basins where peak discharges are of interest, to several days for large drainage basins where water storage is of interest.

Time of Concentration: The time it takes for runoff to travel from the hydraulically most distant part of the watershed to the basin outlet or point of reference.

X-Year Flood: The flood whose magnitude will be equalled or exceeded, on the average, at least once in the next X years.

X-Year Storm: Same as X-year flood except for rainfall.

B

APPENDIX B

PRECIPITATION DISTRIBUTIONS

Table B-1
Six-Hour Precipitation Distributions

	25-year			100-year			500-year			General Storm PMP		
Elapsed Time (min)	DRCOG % 1-hr Rainfall (%)	Incremental Precip (in)	Accumulated Precip (in)	DRCOG % 1-hr Rainfall (%)	Incremental Precip (in)	Accumulated Precip (in)	DRCOG % 1-hr Rainfall (%)	Incremental Precip (in)	Accumulated Precip (in)	DRCOG % 1-hr Rainfall (%)	Incremental Precip (in)	Accumulated Precip (in)
5	1.7	0.035	0.035	1.0	0.027	0.027	1.0	0.033	0.033	1.0	0.130	0.130
10	3.6	0.076	0.111	3.0	0.081	0.108	3.0	0.099	0.132	3.0	0.390	0.520
15	6.6	0.139	0.249	4.6	0.124	0.232	4.6	0.152	0.284	4.6	0.598	1.118
20	11.5	0.242	0.491	8.0	0.216	0.448	8.0	0.264	0.548	8.0	1.040	2.158
25	20.0	0.420	0.911	14.0	0.378	0.826	14.0	0.462	1.010	14.0	1.820	3.978
30	18.5	0.389	1.299	25.0	0.675	1.501	25.0	0.825	1.835	25.0	3.250	7.228
35	8.8	0.185	1.484	14.0	0.378	1.879	14.0	0.462	2.297	14.0	1.820	9.048
40	6.2	0.129	1.613	8.0	0.216	2.095	8.0	0.264	2.561	8.0	1.040	10.088
45	4.4	0.092	1.706	6.2	0.167	2.263	6.2	0.205	2.765	6.2	0.806	10.894
50	4.1	0.086	1.792	5.0	0.135	2.398	5.0	0.165	2.930	5.0	0.650	11.544
55	3.2	0.067	1.859	4.0	0.108	2.506	4.0	0.132	3.062	4.0	0.520	12.064
60	3.2	0.067	1.926	4.0	0.108	2.614	4.0	0.132	3.194	4.0	0.520	12.584
65	3.2	0.067	1.993	4.0	0.108	2.722	4.0	0.132	3.326	4.0	0.520	13.104
70	2.8	0.059	2.052	2.0	0.054	2.776	2.0	0.066	3.392	2.0	0.260	13.364
75	2.8	0.059	2.111	2.0	0.054	2.830	2.0	0.066	3.458	2.0	0.260	13.624
80	2.2	0.045	2.156	1.2	0.032	2.862	1.2	0.040	3.498	1.5	0.200	13.824
85	1.9	0.039	2.195	1.2	0.032	2.894	1.2	0.040	3.538	1.5	0.200	14.024
90	1.7	0.035	2.230	1.2	0.032	2.927	1.2	0.040	3.577	1.5	0.200	14.224
95	1.7	0.035	2.264	1.2	0.032	2.959	1.2	0.040	3.617	1.5	0.200	14.424
100	1.7	0.035	2.299	1.2	0.032	2.992	1.2	0.040	3.656	1.5	0.200	14.624
105	1.7	0.035	2.333	1.2	0.032	3.024	1.2	0.040	3.696	1.5	0.200	14.824
110	1.7	0.035	2.368	1.2	0.032	3.056	1.2	0.040	3.736	1.5	0.200	15.024
115	1.6	0.033	2.401	1.2	0.032	3.089	1.2	0.040	3.775	1.5	0.200	15.224
120	1.4	0.028	2.429	1.2	0.032	3.121	1.2	0.040	3.815	1.5	0.200	15.424
125	0.6	0.012	2.441	0.5	0.014	3.135	0.6	0.021	3.836	1.5	0.190	15.614
130	0.6	0.012	2.453	0.5	0.014	3.149	0.6	0.021	3.857	1.5	0.190	15.804
135	0.6	0.012	2.465	0.5	0.014	3.163	0.6	0.021	3.878	1.5	0.190	15.994
140	0.6	0.012	2.477	0.5	0.014	3.177	0.6	0.021	3.899	1.5	0.190	16.184
145	0.6	0.012	2.489	0.5	0.014	3.191	0.6	0.021	3.920	1.5	0.190	16.374
150	0.6	0.012	2.501	0.5	0.014	3.205	0.6	0.021	3.941	1.5	0.190	16.564
155	0.6	0.012	2.513	0.5	0.014	3.219	0.6	0.021	3.962	1.5	0.190	16.754
160	0.6	0.012	2.525	0.5	0.014	3.233	0.6	0.021	3.983	1.5	0.190	16.944
165	0.6	0.012	2.537	0.5	0.014	3.247	0.6	0.021	4.004	1.5	0.190	17.134
170	0.6	0.012	2.549	0.5	0.014	3.261	0.6	0.021	4.025	1.5	0.190	17.324
175	0.6	0.012	2.561	0.5	0.014	3.275	0.6	0.021	4.046	1.5	0.190	17.514
180	0.6	0.012	2.573	0.5	0.014	3.289	0.6	0.021	4.067	1.4	0.180	17.694
185	0.6	0.012	2.585	0.5	0.014	3.303	0.6	0.021	4.088	1.4	0.180	17.874
190	0.6	0.012	2.597	0.5	0.014	3.317	0.6	0.021	4.109	1.4	0.180	18.054
195	0.6	0.012	2.609	0.5	0.014	3.331	0.6	0.021	4.130	1.4	0.180	18.234
200	0.6	0.012	2.621	0.5	0.014	3.345	0.6	0.021	4.151	1.4	0.180	18.414
205	0.6	0.012	2.633	0.5	0.014	3.359	0.6	0.021	4.172	1.4	0.180	18.594
210	0.6	0.012	2.645	0.5	0.014	3.373	0.6	0.021	4.193	1.4	0.180	18.774
215	0.6	0.012	2.657	0.5	0.014	3.387	0.6	0.021	4.214	1.4	0.180	18.954
220	0.6	0.012	2.669	0.5	0.014	3.401	0.6	0.021	4.235	1.4	0.180	19.134
225	0.6	0.012	2.681	0.5	0.014	3.415	0.6	0.021	4.256	1.4	0.180	19.314
230	0.6	0.012	2.693	0.5	0.014	3.429	0.6	0.021	4.277	1.4	0.180	19.494
235	0.6	0.012	2.705	0.5	0.014	3.443	0.6	0.021	4.298	1.4	0.180	19.674
240	0.6	0.012	2.717	0.5	0.014	3.457	0.6	0.021	4.319	1.4	0.180	19.854
245	0.6	0.012	2.729	0.5	0.014	3.471	0.6	0.021	4.340	1.4	0.180	20.034
250	0.6	0.012	2.741	0.5	0.014	3.485	0.6	0.021	4.361	1.4	0.180	20.214
255	0.6	0.012	2.753	0.5	0.014	3.499	0.6	0.021	4.382	1.4	0.180	20.394
260	0.6	0.012	2.765	0.5	0.014	3.513	0.6	0.021	4.403	1.4	0.180	20.574
265	0.6	0.012	2.777	0.5	0.014	3.527	0.6	0.021	4.424	1.4	0.180	20.754
270	0.6	0.012	2.789	0.5	0.014	3.541	0.6	0.021	4.445	1.4	0.180	20.934
275	0.6	0.012	2.801	0.5	0.014	3.555	0.6	0.021	4.466	1.4	0.180	21.114
280	0.6	0.012	2.813	0.5	0.014	3.569	0.6	0.021	4.487	1.4	0.180	21.294
285	0.6	0.012	2.825	0.5	0.014	3.583	0.6	0.021	4.508	1.4	0.180	21.474
290	0.6	0.012	2.837	0.5	0.014	3.597	0.6	0.021	4.529	1.4	0.180	21.654
295	0.6	0.012	2.849	0.5	0.014	3.611	0.6	0.021	4.550	1.4	0.180	21.834
300	0.6	0.012	2.861	0.5	0.014	3.625	0.6	0.021	4.571	1.3	0.170	22.004
305	0.6	0.012	2.873	0.5	0.014	3.639	0.6	0.021	4.592	1.3	0.170	22.174
310	0.6	0.012	2.885	0.5	0.014	3.653	0.6	0.021	4.613	1.3	0.170	22.344
315	0.6	0.012	2.897	0.5	0.014	3.667	0.6	0.021	4.634	1.3	0.170	22.514
320	0.6	0.012	2.909	0.5	0.014	3.681	0.6	0.021	4.655	1.3	0.170	22.684
325	0.6	0.012	2.921	0.5	0.014	3.695	0.6	0.021	4.676	1.3	0.170	22.854
330	0.6	0.012	2.933	0.5	0.014	3.709	0.6	0.021	4.697	1.3	0.170	23.024
335	0.6	0.012	2.945	0.5	0.014	3.723	0.6	0.021	4.718	1.3	0.170	23.194
340	0.6	0.012	2.957	0.5	0.014	3.737	0.6	0.021	4.739	1.3	0.170	23.364
345	0.6	0.012	2.969	0.5	0.014	3.751	0.6	0.021	4.760	1.3	0.170	23.534
350	0.6	0.012	2.981	0.5	0.014	3.765	0.6	0.021	4.781	1.3	0.170	23.704
355	0.6	0.012	2.993	0.5	0.014	3.779	0.6	0.021	4.802	1.3	0.170	23.874
360	0.6	0.012	3.005	0.5	0.014	3.793	0.6	0.021	4.823	1.3	0.170	24.044
TOTAL	143.1			140.5			146.1			185.0		

Table B-2
24-Hour Precipitation Distributions

24-hr Distrib-ution (%)	Elapsed Time (hr)	25-year Incre-mental Precip (in)	25-year Accum-ulated Precip (in)	100-year Incre-mental Precip (in)	100-year Accum-ulated Precip (in)	500-year Incre-mental Precip (in)	500-year Accum-ulated Precip (in)	General Storm PMP Incre-mental Precip (in)	General Storm PMP Accum-ulated Precip (in)
0.5	0.5	0.021	0.021	0.028	0.028	0.034	0.034	0.186	0.186
1.1	1.0	0.022	0.043	0.029	0.056	0.036	0.070	0.193	0.378
1.6	1.5	0.022	0.066	0.029	0.085	0.036	0.107	0.196	0.574
2.2	2.0	0.024	0.089	0.031	0.116	0.038	0.145	0.206	0.781
2.8	2.5	0.024	0.114	0.032	0.148	0.040	0.185	0.214	0.994
3.5	3.0	0.025	0.139	0.033	0.180	0.041	0.226	0.221	1.215
4.1	3.5	0.027	0.166	0.035	0.215	0.044	0.269	0.234	1.449
4.8	4.0	0.028	0.193	0.036	0.251	0.045	0.314	0.242	1.691
5.6	4.5	0.029	0.222	0.037	0.289	0.047	0.361	0.252	1.943
6.3	5.0	0.031	0.253	0.040	0.329	0.050	0.411	0.270	2.212
7.1	5.5	0.032	0.285	0.042	0.370	0.052	0.463	0.280	2.492
8.0	6.0	0.034	0.319	0.044	0.414	0.055	0.518	0.297	2.790
8.9	6.5	0.036	0.355	0.047	0.461	0.058	0.577	0.315	3.105
9.8	7.0	0.039	0.394	0.050	0.512	0.063	0.640	0.339	3.444
10.9	7.5	0.042	0.436	0.055	0.566	0.068	0.708	0.368	3.812
12.0	8.0	0.046	0.481	0.059	0.626	0.074	0.782	0.399	4.211
13.3	8.5	0.050	0.531	0.065	0.691	0.081	0.863	0.437	4.648
14.7	9.0	0.056	0.587	0.072	0.763	0.090	0.954	0.487	5.135
16.3	9.5	0.063	0.650	0.082	0.845	0.103	1.056	0.553	5.688
18.1	10.0	0.073	0.723	0.095	0.940	0.119	1.175	0.640	6.328
20.4	10.5	0.094	0.817	0.122	1.062	0.152	1.327	0.819	7.147
23.5	11.0	0.124	0.940	0.161	1.223	0.201	1.528	1.082	8.229
28.3	11.5	0.193	1.133	0.251	1.473	0.313	1.841	1.687	9.916
66.3	12.0	1.520	2.653	1.975	3.449	2.469	4.311	13.297	23.212
73.5	12.5	0.288	2.940	0.374	3.823	0.467	4.778	2.517	25.729
77.2	13.0	0.149	3.090	0.194	4.016	0.242	5.021	1.305	27.034
79.9	13.5	0.106	3.196	0.138	4.154	0.172	5.193	0.928	27.962
82.0	14.0	0.083	3.279	0.108	4.262	0.135	5.328	0.728	28.690
83.8	14.5	0.073	3.352	0.095	4.358	0.119	5.447	0.640	29.330
85.4	15.0	0.063	3.415	0.082	4.440	0.103	5.550	0.553	29.883
86.8	15.5	0.055	3.470	0.072	4.512	0.090	5.639	0.483	30.366
88.0	16.0	0.050	3.520	0.065	4.577	0.081	5.721	0.438	30.804
89.1	16.5	0.045	3.566	0.059	4.635	0.073	5.794	0.395	31.199
90.2	17.0	0.042	3.608	0.055	4.690	0.068	5.862	0.368	31.567
91.1	17.5	0.038	3.646	0.050	4.740	0.062	5.925	0.336	31.903
92.1	18.0	0.036	3.682	0.047	4.787	0.059	5.984	0.318	32.221
92.9	18.5	0.034	3.716	0.044	4.831	0.055	6.039	0.298	32.519
93.7	19.0	0.032	3.748	0.042	4.873	0.052	6.091	0.280	32.799
94.5	19.5	0.030	3.778	0.039	4.912	0.049	6.140	0.262	33.061
95.2	20.0	0.029	3.808	0.038	4.950	0.047	6.187	0.255	33.317
95.9	20.5	0.028	3.835	0.036	4.986	0.045	6.232	0.242	33.558
96.5	21.0	0.026	3.861	0.034	5.020	0.042	6.274	0.227	33.786
97.2	21.5	0.026	3.887	0.033	5.053	0.042	6.316	0.224	34.010
97.8	22.0	0.024	3.911	0.031	5.084	0.039	6.355	0.210	34.220
98.4	22.5	0.024	3.934	0.031	5.115	0.038	6.393	0.206	34.426
98.9	23.0	0.022	3.957	0.029	5.144	0.036	6.430	0.196	34.622
99.5	23.5	0.022	3.979	0.029	5.172	0.036	6.466	0.193	34.815
100.0	24.0	0.021	4.000	0.028	5.200	0.034	6.500	0.185	35.000

Table B-3
72-Hour Precipitation Distributions

Elapsed Time (hr)	25-year Incremental Precip (in)	25-year Accumulated Precip (in)	100-year Incremental Precip (in)	100-year Accumulated Precip (in)	500-year Incremental Precip (in)	500-year Accumulated Precip (in)	General Storm PMP Incremental Precip (in)	General Storm PMP Accumulated Precip (in)
1	0.043	0.043	0.056	0.056	0.07	0.070	0.378	0.378
2	0.046	0.089	0.060	0.116	0.075	0.145	0.402	0.781
3	0.050	0.139	0.064	0.180	0.081	0.226	0.434	1.215
4	0.054	0.193	0.071	0.251	0.088	0.314	0.476	1.691
5	0.060	0.253	0.077	0.329	0.097	0.411	0.522	2.212
6	0.066	0.319	0.086	0.414	0.107	0.518	0.577	2.790
7	0.075	0.394	0.097	0.512	0.122	0.640	0.655	3.444
8	0.088	0.481	0.114	0.626	0.142	0.782	0.767	4.211
9	0.106	0.587	0.137	0.763	0.172	0.954	0.924	5.135
10	0.136	0.723	0.177	0.940	0.222	1.175	1.193	6.328
11	0.217	0.940	0.282	1.223	0.353	1.528	1.901	8.229
12	1.712	2.653	2.226	3.449	2.783	4.311	14.984	23.212
13	0.437	3.090	0.568	4.016	0.710	5.021	3.822	27.034
14	0.189	3.279	0.246	4.262	0.307	5.328	1.656	28.690
15	0.136	3.415	0.177	4.440	0.222	5.550	1.194	29.883
16	0.105	3.520	0.137	4.577	0.171	5.721	0.921	30.804
17	0.087	3.608	0.113	4.690	0.142	5.862	0.763	31.567
18	0.075	3.682	0.097	4.787	0.122	5.984	0.654	32.221
19	0.066	3.748	0.086	4.873	0.107	6.091	0.578	32.799
20	0.059	3.808	0.077	4.950	0.096	6.187	0.518	33.317
21	0.054	3.861	0.070	5.020	0.087	6.274	0.469	33.786
22	0.050	3.911	0.064	5.084	0.081	6.355	0.434	34.220
23	0.046	3.957	0.060	5.144	0.075	6.430	0.402	34.622
24	0.043	4.000	0.056	5.200	0.070	6.500	0.378	35.000
25	0.021	4.021	0.023	5.223	0.033	6.533	0.167	35.167
26	0.021	4.042	0.023	5.246	0.033	6.567	0.167	35.333
27	0.021	4.062	0.023	5.269	0.033	6.600	0.167	35.500
28	0.021	4.083	0.023	5.292	0.033	6.633	0.167	35.667
29	0.021	4.104	0.023	5.315	0.033	6.667	0.167	35.833
30	0.021	4.125	0.023	5.337	0.033	6.700	0.167	36.000
31	0.021	4.146	0.023	5.360	0.033	6.733	0.167	36.167
32	0.021	4.167	0.023	5.383	0.033	6.767	0.167	36.333
33	0.021	4.187	0.023	5.406	0.033	6.800	0.167	36.500
34	0.021	4.208	0.023	5.429	0.033	6.833	0.167	36.667
35	0.021	4.229	0.023	5.452	0.033	6.867	0.167	36.833
36	0.021	4.250	0.023	5.475	0.033	6.900	0.167	37.000

Table B-3 (Con't.)
72-Hour Precipitation Distributions (continued)

Elapsed Time (hr)	25-year Incremental Precip (in)	25-year Accumulated Precip (in)	100-year Incremental Precip (in)	100-year Accumulated Precip (in)	500-year Incremental Precip (in)	500-year Accumulated Precip (in)	General Storm PMP Incremental Precip (in)	General Storm PMP Accumulated Precip (in)
37	0.021	4.271	0.023	5.498	0.033	6.933	0.167	37.167
38	0.021	4.292	0.023	5.521	0.033	6.967	0.167	37.333
39	0.021	4.312	0.023	5.544	0.033	7.000	0.167	37.500
40	0.021	4.333	0.023	5.567	0.033	7.033	0.167	37.667
41	0.021	4.354	0.023	5.590	0.033	7.067	0.167	37.833
42	0.021	4.375	0.023	5.612	0.033	7.100	0.167	38.000
43	0.021	4.396	0.023	5.635	0.033	7.133	0.167	38.167
44	0.021	4.417	0.023	5.658	0.033	7.167	0.167	38.333
45	0.021	4.437	0.023	5.681	0.033	7.200	0.167	38.500
46	0.021	4.458	0.023	5.704	0.033	7.233	0.167	38.667
47	0.021	4.479	0.023	5.727	0.033	7.267	0.167	38.833
48	0.021	4.500	0.023	5.750	0.033	7.300	0.167	39.000
49	0.021	4.521	0.023	5.773	0.033	7.333	0.167	39.167
50	0.021	4.542	0.023	5.796	0.033	7.367	0.167	39.333
51	0.021	4.562	0.023	5.819	0.033	7.400	0.167	39.500
52	0.021	4.583	0.023	5.842	0.033	7.433	0.167	39.667
53	0.021	4.604	0.023	5.865	0.033	7.467	0.167	39.833
54	0.021	4.625	0.023	5.887	0.033	7.500	0.167	40.000
55	0.021	4.646	0.023	5.910	0.033	7.533	0.167	40.167
56	0.021	4.667	0.023	5.933	0.033	7.567	0.167	40.333
57	0.021	4.687	0.023	5.956	0.033	7.600	0.167	40.500
58	0.021	4.708	0.023	5.979	0.033	7.633	0.167	40.667
59	0.021	4.729	0.023	6.002	0.033	7.667	0.167	40.833
60	0.021	4.750	0.023	6.025	0.033	7.700	0.167	41.000
61	0.021	4.771	0.023	6.048	0.033	7.733	0.167	41.167
62	0.021	4.792	0.023	6.071	0.033	7.767	0.167	41.333
63	0.021	4.812	0.023	6.094	0.033	7.800	0.167	41.500
64	0.021	4.833	0.023	6.117	0.033	7.833	0.167	41.667
65	0.021	4.854	0.023	6.140	0.033	7.867	0.167	41.833
66	0.021	4.875	0.023	6.162	0.033	7.900	0.167	42.000
67	0.021	4.896	0.023	6.185	0.033	7.933	0.167	42.167
68	0.021	4.917	0.023	6.208	0.033	7.967	0.167	42.333
69	0.021	4.937	0.023	6.231	0.033	8.000	0.167	42.500
70	0.021	4.958	0.023	6.254	0.033	8.033	0.167	42.667
71	0.021	4.979	0.023	6.277	0.033	8.067	0.167	42.833
72	0.021	5.000	0.023	6.300	0.033	8.100	0.167	43.000

Table B-4
1-Hour Local-Storm PMP Distribution

	Local Storm PMP			
Elapsed Time (min)	DRCOG % 1-hr Rainfall (%)	This Study % 1-hr Rainfall (%)	Incremental Precip (in)	Accumulated Precip (in)
5	1.0	1.3	0.136	0.136
10	3.0	3.3	0.350	0.480
15	4.6	4.9	0.521	1.000
20	8.0	8.3	0.885	1.885
25	14.0	14.3	1.527	3.411
30	25.0	25.3	2.704	6.115
35	14.0	14.3	1.527	7.641
40	8.0	8.3	0.885	8.526
45	6.2	6.5	0.692	9.218
50	5.0	5.3	0.564	9.781
55	4.0	4.3	0.457	10.238
60	4.0	4.3	0.457	10.694
TOTAL	96.8	100.0*		

* Precipitation distribution adapted from Urban Drainage and Flood Control District (1969) (DRCOG). DRCOG distribution adjusted uniformly to attain 100 percent of PMP rainfall in 1 hour.

C

APPENDIX C

HYDROLOGIC AND HYDRAULIC INFORMATION FOR STRUCTURES AND CHANNELS PERTINENT TO THE RFP

Table C-1
Hydraulic Characteristics for RFP Channels

DITCH	BOTTOM WIDTH (ft)	SIDE SLOPE	CHANNEL SLOPE (ft/ft)	MAXIMUM DEPTH (ft)	AREA (ft^2)	HYDRAULIC RADIUS (ft)	MANNINGS n	DISCHARGE (cfs)
McKay Bypass Ditch								
Reach 1	14	2:1	0.0002	7.5	218	4.57	0.0225	560
Reach 2	15	2:1	0.0002	8.2	258	4.98	0.0225	700
Reach 3	15	2:1	0.0002	8.5	272	5.13	0.0225	760
Reach 4	16	2:1	0.0002	8.6	286	5.24	0.0225	810
South Interceptor								
Reach 1	5	2:1	0.0002	4.3	59	2.41	0.0225	100
Reach 2	8	2:1	0.0002	5.8	114	3.36	0.0225	240
Reach 3	10	2:1	0.0002	6.6	153	3.87	0.0225	350
Reach 4	14	2:1	0.0002	8.1	245	4.87	0.0225	660
Woman Creek Bypass	27	2:1	0.0002	9.5	437	5.11	0.0225	1,200
Landfill Interceptor Ditches	5	2:1	0.01	3.0	33	1.79	0.0225	320
Upper Church Ditch (metal trough)	2[1]	--	0.01	2.0	6.3	1.0	0.01	94 (18)[2]
McKay Ditch (metal trough)	2.5[1]	--	0.01	2.5	9.8	1.25	0.01	170 (125)[2]

[1] radius of half-cylindrical trough.

[2] State Engineer rated ditch capacity.

Manning's Equation:

$$Q = 1.49/n \; S^{0.5} \; R^{0.667} \; A$$

where Q = discharge (cfs),

n = Manning's channel roughness coefficient,

S = channel slope (ft/ft),

R = hydraulic radius (ft), and

A = channel cross-section area (ft^2).

Table C-2
Basin Characteristics for Coal Creek Watershed

DRAINAGE BASIN	BASIN AREA (mi)	BASIN HEIGHT (Z) (ft)	CHANNEL LENGTH (L) (ft)	BASIN SLOPE (BS) (ft/ft)	CONTOUR LENGTH AT 25% OF BASIN HEIGHT (LC25) (ft)	CONTOUR LENGTH AT 50% OF BASIN HEIGHT (LC50) (ft)	CONTOUR LENGTH AT 75% OF BASIN HEIGHT (LC75) (ft)	AVERAGE BASIN SLOPE (SBAR) (ft/ft)	CURVE NUMBER (CN)	LAG (hr)	TIME OF CONCEN. (Tc) (hr)
Beaver Creek	2.8	2,630	16,400	0.16	16,400	16,400	4,900	0.32	60	0.71	1.18
S. Beaver Creek	2.2	1,315	10,500	0.13	16,400	18,000	14,800	0.26	60	0.54	0.90
Upper Coal Creek	4.0	1,480	16,100	0.09	26,200	14,800	9,800	0.17	60	0.95	1.59
Lower Coal Creek	6.1	2,780	25,000	0.11	29,500	42,600	24,600	0.40	60	0.86	1.43

NOTES:

BS = Z/L

SBAR = 0.25 Z (LC25+LC50+LC75)/ (Basin Area, in ft^2)

LAG = $(L^{0.8} (S+1)^{0.7}) / (1,900 (SBAR*100)^{0.5})$
where S = (1,000/CN)-10

Tc = LAG/0.6

Table C-3
Storage and Conveyance Characteristics
of RFP Diversion Dams

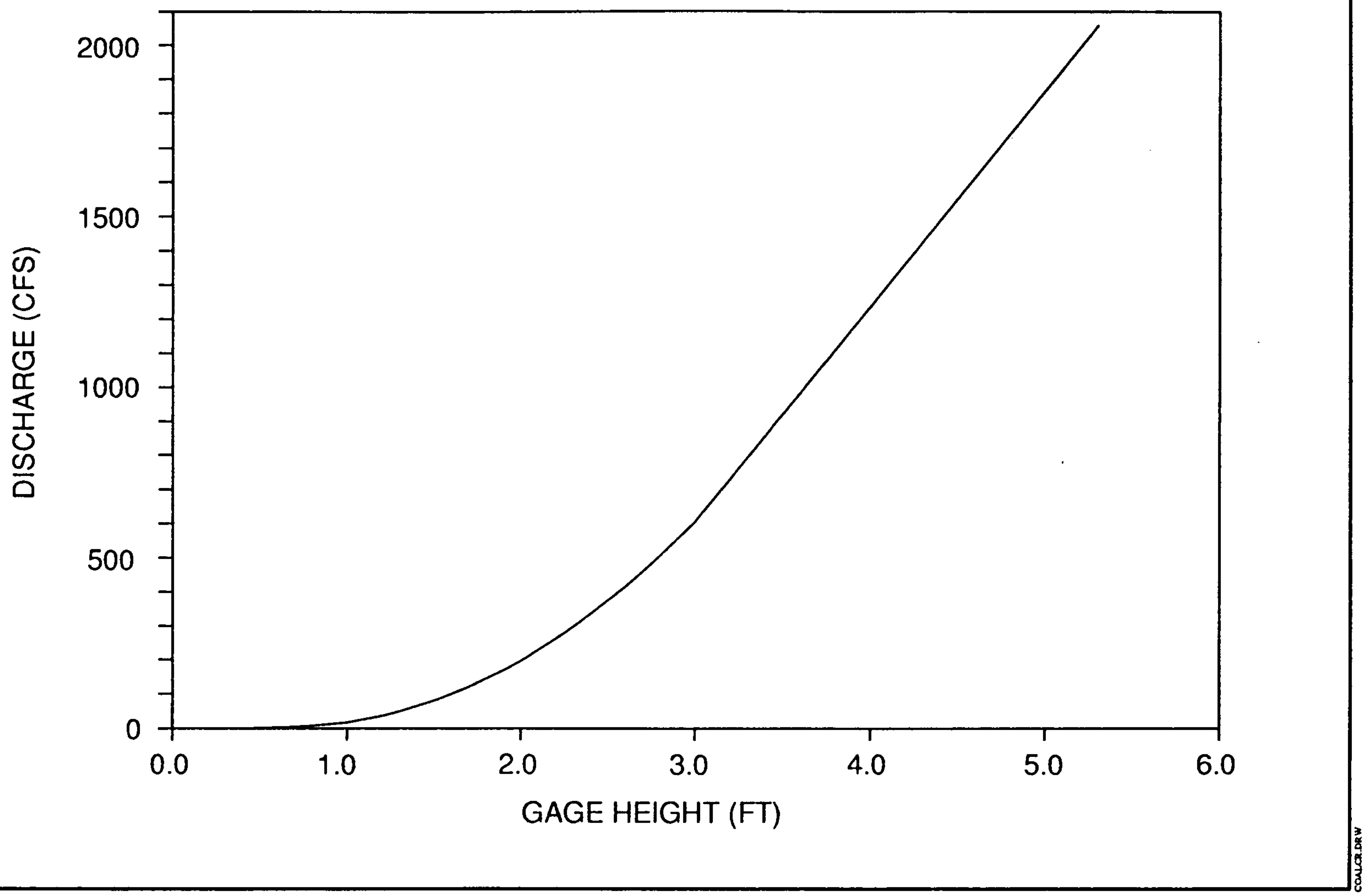
DIVERSION DAM	ELEVATION (ft above MSL)	VOLUME (ac-ft)	DISCHARGE (cfs)
North Walnut Creek[1]	6,039.5	0	0
	6,040	0.04	30
	6,042	0.48	105
	6,044	1.18	285
	6,044.5	1.5	330
Woman Creek[2]	5,767	0	0
	5,768	0.08	155
	5,770	0.54	350
	5,772	1.4	770
	5,774	2.92	1,120
	5,775	4.02	1,300

1 Outlet of N. Walnut Cr. Diversion Dam consists of three 60-in culverts, 44 ft long, with slope = 0.023 ft/ft

2 Outlet of Woman Creek Diversion Dam consists of seven 60-in culverts, 100 ft long, with slope = 0.164 ft/ft

Culvert discharge calculated using techniques in Highway Task Force (1971), assuming inlet control.

Storage volumes based on planimetering from 1" = 200'scale, 2-ft contour-interval maps.

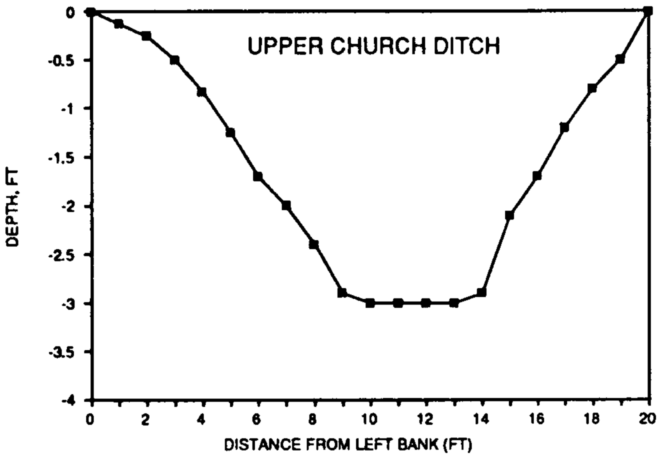


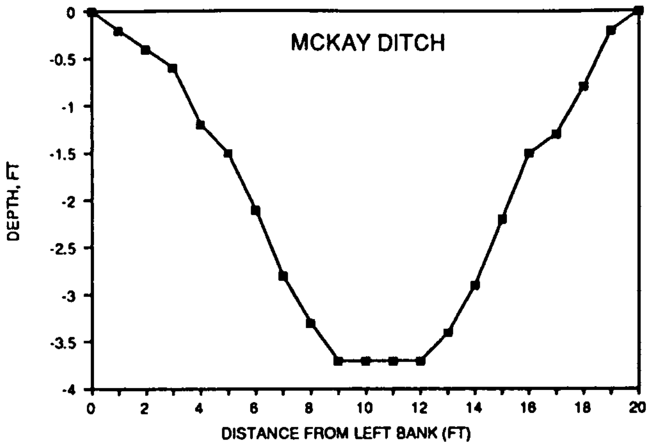
STAGE vs. DISCHARGE RELATION FOR 06730300 - COAL CREEK NEAR PLAINVIEW
(DISCONTINUED USGS/SE STREAM-GAGING STATION)

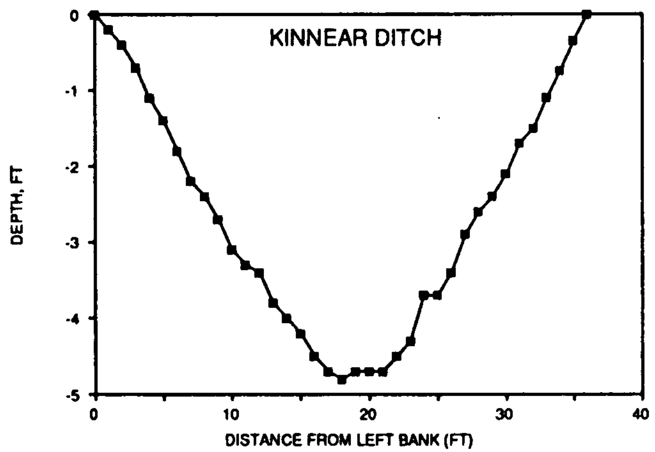
STORM-RUNOFF QUANTITY FOR
VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. C-1







	UPPER CHURCH	MCKAY	KINNEAR
Area, ft	35	40	100
Bottom Width, ft	5	4	6
Channel Slope	0.02	0.02	0.02
Wetted Perimeter, ft	21	22	37.5
Manning's n	0.025	0.025	0.025
Discharge, cfs	410	500	1,600

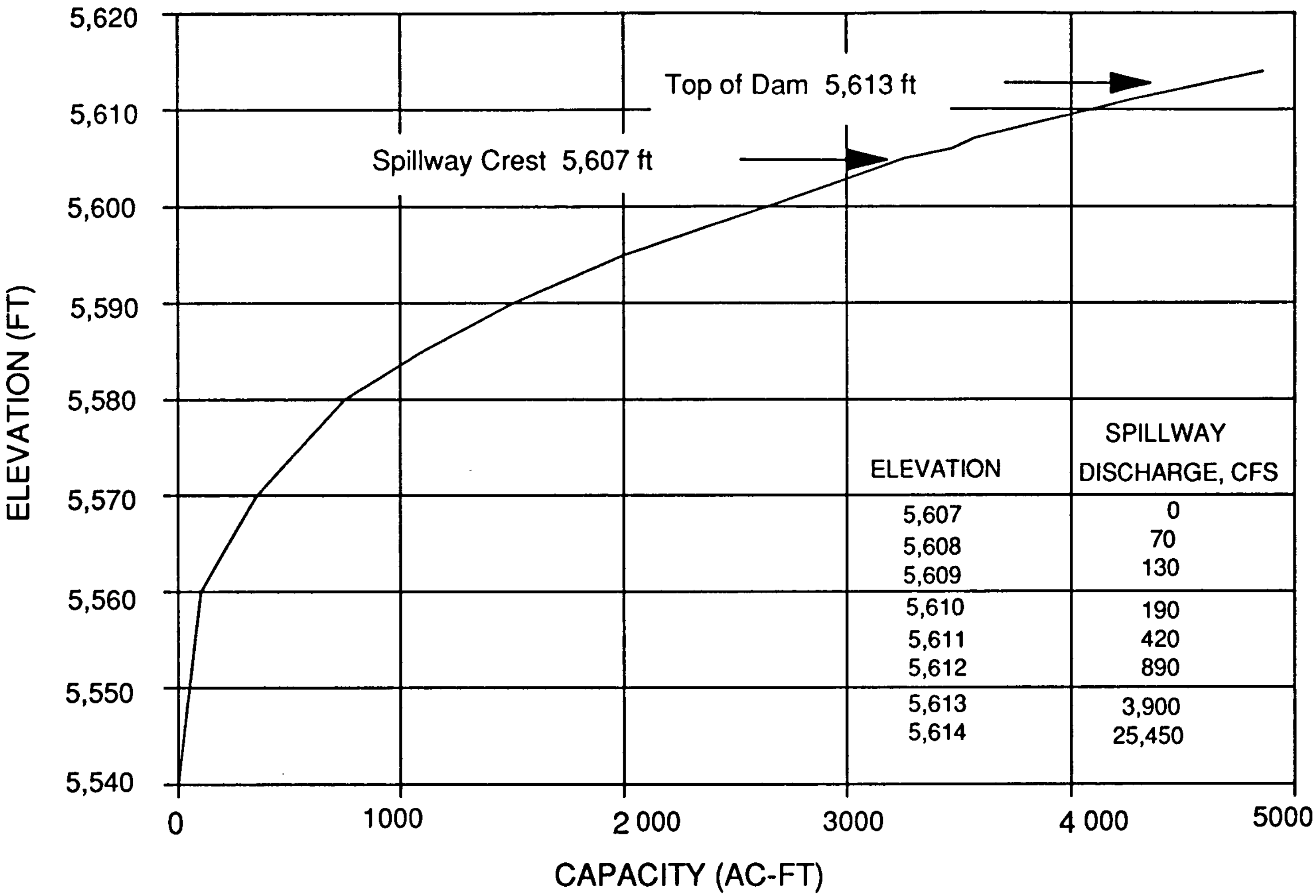
DITCHXC.DRW

CHANNEL-CROSS SECTIONS AND HYDRAULIC CHARACTERISTICS FOR UPPER CHURCH, MCKAY AND KINNEAR DITCHES

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. C-2



ELEVATION	SPILLWAY DISCHARGE, CFS
5,607	0
5,608	70
5,609	130
5,610	190
5,611	420
5,612	890
5,613	3,900
5,614	25,450

CAPACITY OF GREAT WESTERN RESERVOIR vs. ELEVATION AND SPILLWAY DISCHARGE INFORMATION

STORM-RUNOFF QUANTITY FOR VARIOUS DESIGN EVENTS
Zero-Offsite Water Discharge

PROJECT No. 208.0106

FIGURE No. C-3

D

APPENDIX D

MODEL LIMITATIONS

During the course of utilizing the TR-20 model as a part of this investigation, several limitations were discovered. They are as follows:

1) Input rainfall distributions are limited to 100 entries.

When modeling longer-duration storm events, this limitation becomes apparent. For example, when modeling the 72-hour duration event, the time increment for the input precipitation distribution must be approximately 45 minutes or longer. In this study, the 72-hour duration rainfall distribution was the same as the 24-hour distribution for the first 24 hours. That is, the total rainfall amounts for the two distributions were the same at each hour, during the first 24 hours. However, for the 24-hour distribution, rainfall amounts were input for each half hour, whereas, for the 72-hour distribution, rainfall amounts were input for each whole hour. The result was that less detailed rainfall intensity information was available to the model for the 72-hour events, and the apparent rainfall intensity was less. This contributed to the result that peak discharge estimated for the 72-hour events was less than that estimated for the 24-hour events, whereas they should be identical.

2) Output hydrographs are limited to 300 points.

Again, this limitation affects the results of longer-duration events, such as the 72-hour events. In order to obtain correct runoff volume estimates from TR-20, the entire runoff hydrograph must be complete at the end of 300 hydrograph points, or time increments. Therefore, the modeled time increment must be larger for longer-duration events than for shorter-duration events. This results in less-detailed analysis. For example, during this study, the 24-hour events were simulated with a time increment of approximately 5 minutes, whereas, the 72-hour events were simulated with a time increment of approximately 15 minutes. It is judged that the requirement of a longer modeling time increment for the 72-hour events contributed to the discrepancy in peak-flow estimates described in item 1) above.

3) Hydrograph storage locations are limited to 7.

Computer memory storage locations are provided for a maximum of 7 hydrographs. This tends to limit the amount of detail allowed during a watershed simulation. Fewer runoff hydrographs can be retained to be routed downstream and added in at another location.

E

APPENDIX E

SAMPLE TR20 MODEL INPUT FILE

SAMPLE TR20 MODEL INPUT FILE

```
JOB TR-20                                                                                  JOB TR-20     017
TITLE   01 RFP WATERSHED SIMULATION *** 100-YR *** 6- AND 24-HR ***                        TITLE_1       031
TITLE      INCLUDES COAL CREEK INPUT - PONDS EMPTY, HALF FULL AND FULL                     TITLE_2       032
 5 RAINFL 6                       0.0833                                                   RAINFL        020
 8                .027           .108         .232         .448         .826               RAINFL_N      021
 8               1.501          1.879        2.095        2.263        2.398               RAINFL_N      021
 8               2.506          2.614        2.722        2.776        2.830               RAINFL_N      021
 8               2.862          2.894        2.927        2.959        2.992               RAINFL_N      021
 8               3.024          3.056        3.089        3.121        3.131               RAINFL_N      021
 8               3.149          3.163        3.177        3.199        3.205               RAINFL_N      021
 8               3.219          3.233        3.247        3.261        3.275               RAINFL_N      021
 8               3.289          3.303        3.317        3.331        3.345               RAINFL_N      021
 8               3.359          3.373        3.387        3.401        3.415               RAINFL_N      021
 8               3.429          3.443        3.457        3.471        3.485               RAINFL_N      021
 8               3.499          3.513        3.527        3.541        3.555               RAINFL_N      021
 8               3.569          3.583        3.597        3.611        3.625               RAINFL_N      021
 8               3.639          3.653        3.667        3.681        3.695               RAINFL_N      021
 8               3.709          3.723        3.737        3.751        3.765               RAINFL_N      021
 8               3.779          3.793          3.8          3.8          3.8               RAINFL_N      021
 9 ENDTBL                                                                                  ENDTBL        014
 5 RAINFL 5                         0.5                                                    RAINFL        020
 8                .028           .056         .085         .116         .148               RAINFL_N      021
 8                 .18           .215         .251         .289         .329               RAINFL_N      021
 8                 .37           .414         .461         .512         .566               RAINFL_N      021
 8                .626           .691         .763         .845          .94               RAINFL_N      021
 8               1.062          1.223        1.473        3.449        3.823               RAINFL_N      021
 8               4.016          4.154        4.262        4.358         4.44               RAINFL_N      021
 8               4.512          4.577        4.635         4.69         4.74               RAINFL_N      021
 8               4.787          4.831        4.873        4.912         4.95               RAINFL_N      021
 8               4.986           5.02        5.053        5.084        5.115               RAINFL_N      021
 8               5.144          5.172          5.2          5.2          5.2               RAINFL_N      021
 9 ENDTBL                                                                                  ENDTBL        014
 3 STRUCT      01                                                                          STRUCT        029
 8                             5730.0          0.0          0.0                            STRUCT_N      030
 8                             5735.0  0.000000001          4.0                            STRUCT_N      030
 8                             5740.0  0.000000002         10.0                            STRUCT_N      030
 8                             5745.0  0.000000003         23.0                            STRUCT_N      030
 8                             5750.0  0.000000004         46.0                            STRUCT_N      030
 8                             5752.5  0.000000005         60.0                            STRUCT_N      030
 8                             5755.0  0.000000006         73.0                            STRUCT_N      030
 8                             5757.5      0.00001         95.0                            STRUCT_N      030
 8                             5759.0        500.0        112.0                            STRUCT_N      030
 8                             5760.0       1200.0        115.0                            STRUCT_N      030
 8                             5761.0       2200.0        121.0                            STRUCT_N      030
 8                             5762.0       3400.0        130.0                            STRUCT_N      030
 8                             5763.0       4900.0        145.0                            STRUCT_N      030
 8                             5764.0       6640.0        155.0                            STRUCT_N      030
 9 ENDTBL                                                                                  ENDTBL        014
 3 STRUCT      02                                                                          STRUCT        029
 8                             5770.0          0.0          0.0                            STRUCT_N      030
 8                             5775.0   0.00000001          3.0                            STRUCT_N      030
 8                             5780.0   0.00000002          5.0                            STRUCT_N      030
 8                             5785.0   0.00000003         12.0                            STRUCT_N      030
 8                             5790.0   0.00000004         20.0                            STRUCT_N      030
 8                             5795.0   0.00000005         36.0                            STRUCT_N      030
 8                             5800.0   0.00000006         56.0                            STRUCT_N      030
 8                             5804.0      0.00001         78.0                            STRUCT_N      030
 8                             5805.0        200.0         84.0                            STRUCT_N      030
 8                             5806.0        500.0         87.0                            STRUCT_N      030
 8                             5807.0       1000.0         90.0                            STRUCT_N      030
 8                             5808.0       1800.0         97.0                            STRUCT_N      030
 8                             5809.0       2600.0        111.0                            STRUCT_N      030
 8                             5809.7       3200.0        117.0                            STRUCT_N      030
 9 ENDTBL                                                                                  ENDTBL        014
```

SAMPLE TR20 MODEL INPUT FILE

```
3 STRUCT       03                                                                     STRUCT        029
8                            5744.0         0.0         0.0                           STRUCT_N      030
8                            5750.0     0.00001         3.0                           STRUCT_N      030
8                            5752.2     0.00002         8.0                           STRUCT_N      030
8                            5755.0     0.00003        14.0                           STRUCT_N      030
8                            5757.5     0.00004        25.0                           STRUCT_N      030
8                            5760.0     0.00005        35.0                           STRUCT_N      030
8                            5762.5     0.00006        50.0                           STRUCT_N      030
8                            5765.0       0.001        71.0                           STRUCT_N      030
8                            5766.0       500.0        77.0                           STRUCT_N      030
8                            5767.0      1200.0        83.0                           STRUCT_N      030
8                            5768.0      2500.0       100.0                           STRUCT_N      030
8                            5769.0      4000.0       115.0                           STRUCT_N      030
8                            5770.0      6500.0       119.0                           STRUCT_N      030
8                            5771.0      8500.0       125.0                           STRUCT_N      030
8                            5772.0     12000.0       138.0                           STRUCT_N      030
8                            5773.0     14500.0       150.0                           STRUCT_N      030
8                            5774.0     18000.0       170.0                           STRUCT_N      030
8                            5774.4     19000.0       175.0                           STRUCT_N      030
9 ENDTBL                                                                              ENDTBL_       014
3 STRUCT       04                                                                     STRUCT        029
8                            6039.5         0.0         0.0                           STRUCT_N      030
8                            6040.0        30.0        0.04                           STRUCT_N      030
8                            6042.0       105.0        0.48                           STRUCT_N      030
8                            6044.0       285.0        1.18                           STRUCT_N      030
8                            6044.5       330.0        1.45                           STRUCT_N      030
9 ENDTBL                                                                              ENDTBL_       014
3 STRUCT       05                                                                     STRUCT        029
8                            5892.0         0.0         0.0                           STRUCT_N      030
8                            5900.0     0.00001         3.0                           STRUCT_N      030
8                            5905.2     0.00002         4.5                           STRUCT_N      030
8                            5910.0     0.00003         7.5                           STRUCT_N      030
8                            5915.0     0.00004        15.0                           STRUCT_N      030
8                            5918.0     0.00005        21.4                           STRUCT_N      030
8                            5921.0     0.00006        28.0                           STRUCT_N      030
8                            5922.0        45.0        30.0                           STRUCT_N      030
8                            5924.0       160.0        35.0                           STRUCT_N      030
8                            5926.5       350.0        43.5                           STRUCT_N      030
9 ENDTBL                                                                              ENDTBL_       014
3 STRUCT       06                                                                     STRUCT        029
8                            5767.5         0.0         0.0                           STRUCT_N      030
8                            5768.0       155.0        0.08                           STRUCT_N      030
8                            5770.0       350.0        0.54                           STRUCT_N      030
8                            5772.0       770.0        1.40                           STRUCT_N      030
8                            5774.0      1120.0        2.92                           STRUCT_N      030
8                            5775.0      1300.0        4.02                           STRUCT_N      030
9 ENDTBL                                                                              ENDTBL_       014
3 STRUCT       07                                                                     STRUCT        029
8                            5550.0         0.0         0.0                           STRUCT_N      030
8                            5560.00.0000000001       150.0                           STRUCT_N      030
8                            5570.00.0000000002       400.0                           STRUCT_N      030
8                            5580.00.0000000003       750.0                           STRUCT_N      030
8                            5590.00.0000000004      1500.0                           STRUCT_N      030
8                            5595.00.0000000005      2000.0                           STRUCT_N      030
8                            5600.00.0000000006      2700.0                           STRUCT_N      030
8                            5605.00.0000000007      3253.0                           STRUCT_N      030
8                            5606.00.0000000008      3470.0                           STRUCT_N      030
8                            5607.00.0000000009      3569.0                           STRUCT_N      030
8                            5608.0        70.0      3734.0                           STRUCT_N      030
8                            5609.0       130.0      3905.0                           STRUCT_N      030
8                            5610.0       190.0      4084.0                           STRUCT_N      030
8                            5611.0       420.0      4268.0                           STRUCT_N      030
8                            5612.0       890.0      4459.0                           STRUCT_N      030
8                            5613.0      3900.0      4656.0                           STRUCT_N      030
8                            5614.0     25450.0      4859.0                           STRUCT_N      030
```

SAMPLE TR20 MODEL INPUT FILE

```
9 ENDTBL                                                                 ENDTBL     014
6 RUNOFF 1 001       1         2.8      60.0      1.18                   RUNOFF     027
6 RUNOFF 1 002       2         2.2      60.0      0.90                   RUNOFF     027
6 ADDHYD 4 003   1 2 3                                                   ADDHYD     001
6 REACH  3 004   3   4      3600.0      1.75      1.45                   REACH      022
6 RUNOFF 1 005       5         4.0      60.0      1.59                   RUNOFF     027
6 ADDHYD 4 006   4 5 6                                                   ADDHYD     001
6 REACH  3 007   6   7     25000.0      1.75      1.45                   REACH      022
6 RUNOFF 1 008       1         6.1      60.0      1.43                   RUNOFF     027
6 ADDHYD 4 009   7 1 2                               1     1   1         ADDHYD     001
6 DIVERT 6 009   2 1 3       600.0                10.1     1   1         DIVERT     010
6 DIVERT 6 010   3 4 5        94.0                11.1     1   1         DIVERT     010
6 DIVERT 6 011   5 6 7       170.0                   1     1   1         DIVERT     010
6 REACH  3 012   4   3      9500.0       2.5     1.451     1   1         REACH      022
6 REACH  3 013   6   4     11000.0       2.5     1.451     1   1         REACH      022
6 ADDHYD 4 013   3 4 6                               1     1   1         ADDHYD     001
6 REACH  3 014   6   3      7000.0       2.0      1.51     1   1         REACH      022
6 RUNOFF 1 014       2        0.54      76.0     1.891     1   1         RUNOFF     027
6 ADDHYD 4 014   2 3 4                               1     1 1 1         ADDHYD     001
6 RESVOR 2     04 4  5      6039.5                   1     1   1         RESVOR     026
6 DIVERT 6 015   5 6 4       330.0               36.01     1   1         DIVERT     010
6 REACH  3 016   6   5      1600.0       0.4      1.51     1   1         REACH      022
6 RUNOFF 1 016       6        0.03      74.0     0.931     1   1         RUNOFF     027
6 ADDHYD 4 016   6 5 3                               1     1   1         ADDHYD     001
6 DIVERT 6 017   3 6 5       561.0               18.01     1   1         DIVERT     010
6 RUNOFF 1 018       7        0.03      77.0     0.721     1   1         RUNOFF     027
6 ADDHYD 4 018   7 5 2                               1     1   1         ADDHYD     001
6 DIVERT 6 019   2 5 7       320.0               25.01     1   1         DIVERT     010
6 REACH  3 020   6   1      2500.0       0.4      1.51     1   1         REACH      022
6 RUNOFF 1 020       2       0.082      74.0     1.101     1   1         RUNOFF     027
6 ADDHYD 4 020   1 2 3                               1     1   1         ADDHYD     001
6 DIVERT 6 021   3 1 2       704.0               23.01     1   1         DIVERT     010
6 RUNOFF 1 022       6        0.03      77.0     0.991     1   1         RUNOFF     027
6 ADDHYD 4 023   2 6 3                               1     1   1         ADDHYD     001
6 DIVERT 6 024   3 6 2       320.0               25.01     1   1         DIVERT     010
6 ADDHYD 4 025   2 7 3                               1     1   1         ADDHYD     001
6 RUNOFF 1 026       2        0.05      77.0     0.441     1   1         RUNOFF     027
6 ADDHYD 4 02605 2 3 7                               1     1   1         ADDHYD     001
6 RESVOR 2     05 7  2      5919.0                   1     1 1 1         RESVOR     026
6 ADDHYD 4 027   5 6 7                               1     1   1         ADDHYD     001
6 ADDHYD 4 027   7 2 5                               1     1   1         ADDHYD     001
6 REACH  3 028   1   2      3600.0       0.4      1.51     1   1         REACH      022
6 RUNOFF 1 028       7       0.137      74.0     1.411     1   1         RUNOFF     027
6 ADDHYD 4 028   2 7 1                               1     1   1         ADDHYD     001
6 DIVERT 6 029   1 2 7       758.0               30.01     1   1         DIVERT     010
6 ADDHYD 4 030   7 5 1                               1     1   1         ADDHYD     001
6 REACH  3 031   1   5      6000.0       2.0      1.51     1   1         REACH      022
6 RUNOFF 1 032       1        0.38      77.0     1.091     1   1         RUNOFF     027
6 ADDHYD 4 032   1 5 7                               1     1   1         ADDHYD     001
6 REACH  3 033   2   1      2600.0      0.35      1.51     1   1         REACH      022
6 RUNOFF 1 034       2       0.176      74.0     0.871     1   1         RUNOFF     027
6 ADDHYD 4 035   2 1 5                               1 1   1 1 1         ADDHYD     001
6 REACH  3 036   4   2     10500.0       2.0      1.51     1   1         REACH      022
6 RUNOFF 1 03701     4        0.60      81.0     1.291     1   1         RUNOFF     027
6 ADDHYD 4 03701 2 4 1                               1     1   1         ADDHYD     001
6 RESVOR 2     01 1  2      5730.0                   1     1 1 1         RESVOR     026
6 ADDHYD 4 038   2 7 4                               1     1   1         ADDHYD     001
6 RUNOFF 1 03902     2        0.50      87.0     0.961     1   1         RUNOFF     027
6 RESVOR 2     02 2  7      5770.0                   1     1 1 1         RESVOR     026
6 REACH  3 040   7   2      1600.0       2.0      1.51     1   1         REACH      022
6 RUNOFF 1 041       7        0.08      74.0     0.311     1   1         RUNOFF     027
6 ADDHYD 4 041   2 7 3                               1     1   1         ADDHYD     001
6 ADDHYD 4 041   3 4 7                               1 1   1 1 1         ADDHYD     001
6 REACH  3 042   7   3      5000.0       2.0      1.51     1   1         REACH      022
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SAMPLE TR20 MODEL INPUT FILE

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6 REACH  3 043     5   4      6000.0        2.0        1.51     1   1          REACH          022
6 ADDHYD 4 044     3 4 5                                  1     1   1          ADDHYD         001
6 RUNOFF 1 044         7        0.69       76.0       1.031     1   1          RUNOFF         027
6 ADDHYD 4 045     7 5 3                                  1 1   1 1 1          ADDHYD         001
6 REACH  3 046     3   5      6200.0        1.2        1.51     1   1          REACH          022
6 RUNOFF 1 047         1        0.35       77.0       0.781     1   1          RUNOFF         027
6 REACH  3 048     1   2      5100.0        2.0        1.51     1   1          REACH          022
6 ADDHYD 4 048     2 5 1                                  1     1   1          ADDHYD         001
6 RUNOFF 1 049         2        0.17       73.0       2.841     1   1          RUNOFF         027
6 REACH  3 050     2   3      5500.0        3.0        1.51     1   1          REACH          022
6 ADDHYD 4 050     3 1 2                                  1     1   1          ADDHYD         001
6 RUNOFF 1 051         1        1.25       79.0       1.011     1   1          RUNOFF         027
6 ADDHYD 4 051     1 2 3                                  1     1 1 1          ADDHYD         001
6 RESVOR 2      07 3   1      5600.0                      1 1   1 1 1          RESVOR         026
6 RUNOFF 1 052         1         2.8       60.0       1.18                     RUNOFF         027
6 RUNOFF 1 053         2         2.2       60.0       0.90                     RUNOFF         027
6 ADDHYD 4 054     1 2 3                                                       ADDHYD         001
6 REACH  3 055     3   4      3600.0       1.75       1.45                     REACH          022
6 RUNOFF 1 056         5         4.0       60.0       1.59                     RUNOFF         027
6 ADDHYD 4 057     4 5 6                                                       ADDHYD         001
6 REACH  3 058     6   7     25000.0       1.75       1.45                     REACH          022
6 RUNOFF 1 059         1         6.1       60.0       1.43                     RUNOFF         027
6 ADDHYD 4 059     7 1 2                                                       ADDHYD         001
6 DIVERT 6 060     2 1 3       600.0                  61.0                     DIVERT         010
6 DIVERT 6 061     3 4 5        94.0                  62.0                     DIVERT         010
6 DIVERT 6 062     5 6 7       170.0                  63.0                     DIVERT         010
6 DIVERT 6 063     7 1 2      1600.0                      1     1   1          DIVERT         010
6 REACH  3 064     1   2      9000.0        2.5        1.51     1   1          REACH          022
6 RUNOFF 1 065         1        0.59       73.0       1.991     1   1          RUNOFF         027
6 ADDHYD 4 065     2 1 3                                  1     1   1          ADDHYD         001
6 REACH  3 070     3   1     16200.0        2.0        1.51     1   1          REACH          022
6 RUNOFF 1 071         2        1.42       72.0       2.301     1   1          RUNOFF         027
6 ADDHYD 4 071     1 2 3                                  1     1   1          ADDHYD         001
6 RUNOFF 1 072         1        0.05       77.0       0.381     1   1          RUNOFF         027
6 DIVERT 6 072     1 2 4       100.0                  73.01     1   1          DIVERT         010
6 REACH  3 073     4   1      5700.0        2.0        1.51     1   1          REACH          022
6 ADDHYD 4 073     1 3 4                                  1     1   1          ADDHYD         001
6 REACH  3 074     2   3      1200.0        0.7        1.41     1   1          REACH          022
6 RUNOFF 1 075         1        0.04       77.0       0.311     1   1          RUNOFF         027
6 ADDHYD 4 075     1 3 2                                  1     1   1          ADDHYD         001
6 DIVERT 6 076     2 1 3       240.0                  77.01     1   1          DIVERT         010
6 REACH  3 077     3   2      4100.0        2.0        1.51     1   1          REACH          022
6 ADDHYD 4 078     2 4 3                                  1     1   1          ADDHYD         001
6 REACH  3 079     1   2      1000.0        0.6       1.451     1   1          REACH          022
6 RUNOFF 1 080         1        0.03       77.0       0.271     1   1          RUNOFF         027
6 ADDHYD 4 080     1 2 4                                  1     1   1          ADDHYD         001
6 DIVERT 6 081     4 1 2       350.0                  82.01     1   1          DIVERT         010
6 REACH  3 082     2   4      2600.0        2.0        1.51     1   1
6 ADDHYD 4 083     4 3 2                                  1     1   1
6 REACH  3 084     1   4      3500.0        0.5        1.51     1   1          REACH          022
6 RUNOFF 1 085         3        0.20       77.0       0.681     1   1          RUNOFF         027
6 ADDHYD 4 085     3 4 1                                  1     1   1          ADDHYD         001
6 DIVERT 6 086     1 3 4       660.0                  87.01     1   1          DIVERT         010
6 REACH  3 087     4   1      1000.0        0.3        1.61     1   1          REACH          022
6 ADDHYD 4 087     1 2 4                                  1     1 1 1          ADDHYD         001
6 RESVOR 2      06 4   5      5767.5                      1     1   1          RESVOR         026
6 DIVERT 6 088     5 7 6      1200.0                  89.01     1   1          DIVERT         010
6 ADDHYD 4 089     6 3 1                                  1     1   1          ADDHYD         001
6 RESVOR 2      03 1   2      5744.0                      1     1   1          RESVOR         026
6 ADDHYD 4 090     2 7 1                                  1     1   1          ADDHYD         001
6 REACH  3 091     1   2      5800.0        2.0        1.51     1   1          REACH          022
6 RUNOFF 1 092         1        0.76       73.0       1.081     1   1          RUNOFF         027
6 ADDHYD 4 092     1 2 3                                  1 1   1 1 1          ADDHYD         001
  ENDATA                                                                       ENDATA         011
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SAMPLE TR20 MODEL INPUT FILE

```
7 INCREM 6                    0.030                                            INCREM          015
7 COMPUT 7 001   092            0.0         1.0         1.06 2  01  01         COMPUT          005
  ENDCMP 1                                                                     ENDCMP          012
7 INCREM 6                   0.0833                                            INCREM          015
7 COMPUT 7 001   092            0.0         1.0         1.05 2  01  02         COMPUT          005
  ENDCMP 1                                                                     ENDCMP          012
7 ALTER  3                                                                     ALTER           002
6 DIVERT 6 009   2 1 3        600.0                     10.                    DIVERT          010
6 DIVERT 6 010   3 4 5         94.0                     11.                    DIVERT          010
6 DIVERT 6 011   5 6 7        170.0                                            DIVERT          010
6 REACH  3 012   4   3       9500.0         2.5        1.45                    REACH           022
6 REACH  3 013   6   4      11000.0         2.5        1.45                    REACH           022
6 ADDHYD 4 013   3 4 6                                                         ADDHYD          001
6 REACH  3 014   6   3       7000.0         2.0        1.5                     REACH           022
6 RUNOFF 1 014       2         0.54        76.0        1.89                    RUNOFF          027
6 ADDHYD 4 014   2 3 4                                                         ADDHYD          001
6 RESVOR 2    04 4   5       6039.5                                            RESVOR          026
6 DIVERT 6 015   5 6 4        330.0                    36.0                    DIVERT          010
6 REACH  3 016   6   5       1600.0         0.4        1.5                     REACH           022
6 RUNOFF 1 016       6         0.03        74.0        0.93                    RUNOFF          027
6 ADDHYD 4 016   6 5 3                                                         ADDHYD          001
6 DIVERT 6 017   3 6 5        561.0                    18.0                    DIVERT          010
6 RUNOFF 1 018       7         0.03        77.0        0.72                    RUNOFF          027
6 ADDHYD 4 018   7 5 2                                                         ADDHYD          001
6 DIVERT 6 019   2 5 7        320.0                    25.0                    DIVERT          010
6 REACH  3 020   6   1       2500.0         0.4        1.5                     REACH           022
6 RUNOFF 1 020       2        0.082        74.0        1.10                    RUNOFF          027
6 ADDHYD 4 020   1 2 3                                                         ADDHYD          001
6 DIVERT 6 021   3 1 2        704.0                    23.0                    DIVERT          010
6 RUNOFF 1 022       6         0.03        77.0        0.99                    RUNOFF          027
6 ADDHYD 4 023   2 6 3                                                         ADDHYD          001
6 DIVERT 6 024   3 6 2        320.0                    25.0                    DIVERT          010
6 ADDHYD 4 025   2 7 3                                                         ADDHYD          001
6 RUNOFF 1 026       2         0.05        77.0        0.44                    RUNOFF          027
6 ADDHYD 4 02605 2 3 7                                                         ADDHYD          001
6 RESVOR 2    05 7   2       5919.0                                            RESVOR          026
6 ADDHYD 4 027   5 6 7                                                         ADDHYD          001
6 ADDHYD 4 027   7 2 5                                                         ADDHYD          001
6 REACH  3 028   1   2       3600.0         0.4        1.5                     REACH           022
6 RUNOFF 1 028       7        0.137        74.0        1.41                    RUNOFF          027
6 ADDHYD 4 028   2 7 1                                                         ADDHYD          001
6 DIVERT 6 029   1 2 7        758.0                    30.0                    DIVERT          010
6 ADDHYD 4 030   7 5 1                                                         ADDHYD          001
6 REACH  3 031   1   5       6000.0         2.0        1.5                     REACH           022
6 RUNOFF 1 032       1         0.38        77.0        1.09                    RUNOFF          027
6 ADDHYD 4 032   1 5 7                                                         ADDHYD          001
6 REACH  3 033   2   1       2600.0        0.35        1.5                     REACH           022
6 RUNOFF 1 034       2        0.176        74.0        0.87                    RUNOFF          027
6 ADDHYD 4 035   2 1 5                                                         ADDHYD          001
6 REACH  3 036   4   2      10500.0         2.0        1.5                     REACH           022
6 RUNOFF 1 03701     4         0.60        81.0        1.29                    RUNOFF          027
6 ADDHYD 4 03701 2 4 1                                                         ADDHYD          001
6 RESVOR 2    01 1   2       5750.5                        1     1 1 1         RESVOR          026
6 ADDHYD 4 038   2 7 4                                     1     1   1         ADDHYD          001
6 RUNOFF 1 03902     2         0.50        87.0        0.961     1   1         RUNOFF          027
6 RESVOR 2    02 2   7       5795.5                        1     1 1 1         RESVOR          026
6 REACH  3 040   7   2       1600.0         2.0        1.51      1   1         REACH           022
6 RUNOFF 1 041       7         0.08        74.0        0.311     1   1         RUNOFF          027
6 ADDHYD 4 041   2 7 3                                     1     1   1         ADDHYD          001
6 ADDHYD 4 041   3 4 7                                     1 1   1 1 1         ADDHYD          001
6 REACH  3 042   7   3       5000.0         2.0        1.51      1   1         REACH           022
6 REACH  3 043   5   4       6000.0         2.0        1.51      1   1         REACH           022
6 ADDHYD 4 044   3 4 5                                     1     1   1         ADDHYD          001
6 RUNOFF 1 044       7         0.69        76.0        1.031     1   1         RUNOFF          027
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SAMPLE TR20 MODEL INPUT FILE

```
6 ADDHYD 4 045    7 5 3                                          1 1    1 1 1         ADDHYD        001
6 REACH  3 046    3   5         6200.0         1.2          1.51        1   1         REACH         022
6 RUNOFF 1 047        1           0.35        77.0          0.78                      RUNOFF        027
6 REACH  3 048    1   2         5100.0         2.0           1.5                      REACH         022
6 ADDHYD 4 048    2 5 1                                        1        1   1         ADDHYD        001
6 RUNOFF 1 049        2           0.17        73.0          2.84                      RUNOFF        027
6 REACH  3 050    2   3         5500.0         3.0           1.5                      REACH         022
6 ADDHYD 4 050    3 1 2                                        1        1   1         ADDHYD        001
6 RUNOFF 1 051        1           1.25        79.0          1.01                      RUNOFF        027
6 ADDHYD 4 051    1 2 3                                        1        1 1 1         ADDHYD        001
6 RESVOR 2     07 3   1         5600.0                         1 1      1 1 1         RESVOR        026
6 RUNOFF 1 052        1            2.8        60.0          1.18                      RUNOFF        027
6 RUNOFF 1 053        2            2.2        60.0          0.90                      RUNOFF        027
6 ADDHYD 4 054    1 2 3                                                               ADDHYD        001
6 REACH  3 055    3   4         3600.0        1.75          1.45                      REACH         022
6 RUNOFF 1 056        5            4.0        60.0          1.59                      RUNOFF        027
6 ADDHYD 4 057    4 5 6                                                               ADDHYD        001
6 REACH  3 058    6   7        25000.0        1.75          1.45                      REACH         022
6 RUNOFF 1 059        1            6.1        60.0          1.43                      RUNOFF        027
6 ADDHYD 4 059    7 1 2                                                               ADDHYD        001
6 DIVERT 6 060    2 1 3          600.0                      61.0                      DIVERT        010
6 DIVERT 6 061    3 4 5           94.0                      62.0                      DIVERT        010
6 DIVERT 6 062    5 6 7          170.0                      63.0                      DIVERT        010
6 DIVERT 6 063    7 1 2         1600.0                                                DIVERT        010
6 REACH  3 064    1   2         9000.0         2.5           1.5                      REACH         022
6 RUNOFF 1 065        1           0.59        73.0          1.99                      RUNOFF        027
6 ADDHYD 4 065    2 1 3                                                               ADDHYD        001
6 REACH  3 070    3   1        16200.0         2.0           1.5                      REACH         022
6 RUNOFF 1 071        2           1.42        72.0          2.30                      RUNOFF        027
6 ADDHYD 4 071    1 2 3                                                               ADDHYD        001
6 RUNOFF 1 072        1           0.05        77.0          0.38                      RUNOFF        027
6 DIVERT 6 072    1 2 4          100.0                      73.0                      DIVERT        010
6 REACH  3 073    4   1         5700.0         2.0           1.5                      REACH         022
6 ADDHYD 4 073    1 3 4                                                               ADDHYD        001
6 REACH  3 074    2   3         1200.0         0.7           1.4                      REACH         022
6 RUNOFF 1 075        1           0.04        77.0          0.31                      RUNOFF        027
6 ADDHYD 4 075    1 3 2                                                               ADDHYD        001
6 DIVERT 6 076    2 1 3          240.0                      77.0                      DIVERT        010
6 REACH  3 077    3   2         4100.0         2.0           1.5                      REACH         022
6 ADDHYD 4 078    2 4 3                                                               ADDHYD        001
6 REACH  3 079    1   2         1000.0         0.6          1.45                      REACH         022
6 RUNOFF 1 080        1           0.03        77.0          0.27                      RUNOFF        027
6 ADDHYD 4 080    1 2 4                                                               ADDHYD        001
6 DIVERT 6 081    4 1 2          350.0                      82.0                      DIVERT        010
6 REACH  3 082    2   4         2600.0         2.0           1.5
6 ADDHYD 4 083    4 3 2
6 REACH  3 084    1   4         3500.0         0.5           1.5                      REACH         022
6 RUNOFF 1 085        3           0.20        77.0          0.68                      RUNOFF        027
6 ADDHYD 4 085    3 4 1                                                               ADDHYD        001
6 DIVERT 6 086    1 3 4          660.0                      87.0                      DIVERT        010
6 REACH  3 087    4   1         1000.0         0.3           1.6                      REACH         022
6 ADDHYD 4 087    1 2 4                                                               ADDHYD        001
6 RESVOR 2     06 4   5         5767.5                                                RESVOR        026
6 DIVERT 6 088    5 7 6         1200.0                      89.0                      DIVERT        010
6 ADDHYD 4 089    6 3 1                                                               ADDHYD        001
6 RESVOR 2     03 1   2         5760.0                         1        1 1 1         RESVOR        026
6 ADDHYD 4 090    2 7 1                                        1        1   1         ADDHYD        001
6 REACH  3 091    1   2         5800.0         2.0          1.51        1   1         REACH         022
6 RUNOFF 1 092        1           0.76        73.0          1.08                      RUNOFF        027
6 ADDHYD 4 092    1 2 3                                          1 1    1 1 1         ADDHYD        001
7 INCREM 6                        0.03                                                INCREM        015
7 COMPUT 7 001    092              0.0         1.0          1.06 2   02   01          COMPUT        005
  ENDCMP 1                                                                            ENDCMP        012
7 INCREM 6                      0.0833                                                INCREM        015
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SAMPLE TR20 MODEL INPUT FILE

```
7 COMPUT 7 001   092            0.0         1.0         1.05 2  02  02          COMPUT         005
  ENDCMP 1                                                                      ENDCMP         012
7 ALTER  3                                                                      ALTER          002
6 DIVERT 6 009   2 1 3        600.0                     10.                     DIVERT         010
6 DIVERT 6 010   3 4 5         94.0                     11.                     DIVERT         010
6 DIVERT 6 011   5 6 7        170.0                                             DIVERT         010
6 REACH  3 012   4   3       9500.0         2.5        1.45                     REACH          022
6 REACH  3 013   6   4      11000.0         2.5        1.45                     REACH          022
6 ADDHYD 4 013   3 4 6                                                          ADDHYD         001
6 REACH  3 014   6   3       7000.0         2.0         1.5                     REACH          022
6 RUNOFF 1 014       2         0.54        76.0        1.89                     RUNOFF         027
6 ADDHYD 4 014   2 3 4                                                          ADDHYD         001
6 RESVOR 2    04 4   5       6039.5                                             RESVOR         026
6 DIVERT 6 015   5 6 4        330.0                    36.0                     DIVERT         010
6 REACH  3 016   6   5       1600.0         0.4         1.5                     REACH          022
6 RUNOFF 1 016       6         0.03        74.0        0.93                     RUNOFF         027
6 ADDHYD 4 016   6 5 3                                                          ADDHYD         001
6 DIVERT 6 017   3 6 5        561.0                    18.0                     DIVERT         010
6 RUNOFF 1 018       7         0.03        77.0        0.72                     RUNOFF         027
6 ADDHYD 4 018   7 5 2                                                          ADDHYD         001
6 DIVERT 6 019   2 5 7        320.0                    25.0                     DIVERT         010
6 REACH  3 020   6   1       2500.0         0.4         1.5                     REACH          022
6 RUNOFF 1 020       2        0.082        74.0        1.10                     RUNOFF         027
6 ADDHYD 4 020   1 2 3                                                          ADDHYD         001
6 DIVERT 6 021   3 1 2        704.0                    23.0                     DIVERT         010
6 RUNOFF 1 022       6         0.03        77.0        0.99                     RUNOFF         027
6 ADDHYD 4 023   2 6 3                                                          ADDHYD         001
6 DIVERT 6 024   3 6 2        320.0                    25.0                     DIVERT         010
6 ADDHYD 4 025   2 7 3                                                          ADDHYD         001
6 RUNOFF 1 026       2         0.05        77.0        0.44                     RUNOFF         027
6 ADDHYD 4 02605 2 3 7                                                          ADDHYD         001
6 RESVOR 2    05 7   2       5919.0                                             RESVOR         026
6 ADDHYD 4 027   5 6 7                                                          ADDHYD         001
6 ADDHYD 4 027   7 2 5                                                          ADDHYD         001
6 REACH  3 028   1   2       3600.0         0.4         1.5                     REACH          022
6 RUNOFF 1 028       7        0.137        74.0        1.41                     RUNOFF         027
6 ADDHYD 4 028   2 7 1                                                          ADDHYD         001
6 DIVERT 6 029   1 2 7        758.0                    30.0                     DIVERT         010
6 ADDHYD 4 030   7 5 1                                                          ADDHYD         001
6 REACH  3 031   1   5       6000.0         2.0         1.5                     REACH          022
6 RUNOFF 1 032       1         0.38        77.0        1.09                     RUNOFF         027
6 ADDHYD 4 032   1 5 7                                                          ADDHYD         001
6 REACH  3 033   2   1       2600.0        0.35         1.5                     REACH          022
6 RUNOFF 1 034       2        0.176        74.0        0.87                     RUNOFF         027
6 ADDHYD 4 035   2 1 5                                                          ADDHYD         001
6 REACH  3 036   4   2      10500.0         2.0         1.5                     REACH          022
6 RUNOFF 1 03701     4         0.60        81.0        1.29                     RUNOFF         027
6 ADDHYD 4 03701 2 4 1                                                          ADDHYD         001
6 RESVOR 2    01 1   2       5757.5                         1      1 1 1         RESVOR         026
6 ADDHYD 4 038   2 7 4                                      1      1   1         ADDHYD         001
6 RUNOFF 1 03902     2         0.50        87.0        0.961      1   1         RUNOFF         027
6 RESVOR 2    02 2   7       5804.0                         1      1 1 1         RESVOR         026
6 REACH  3 040   7   2       1600.0         2.0         1.51      1   1         REACH          022
6 RUNOFF 1 041       7         0.08        74.0        0.311      1   1         RUNOFF         027
6 ADDHYD 4 041   2 7 3                                      1      1   1         ADDHYD         001
6 ADDHYD 4 041   3 4 7                                      1 1    1 1 1         ADDHYD         001
6 REACH  3 042   7   3       5000.0         2.0         1.51      1   1         REACH          022
6 REACH  3 043   5   4       6000.0         2.0         1.51      1   1         REACH          022
6 ADDHYD 4 044   3 4 5                                      1      1   1         ADDHYD         001
6 RUNOFF 1 044       7         0.69        76.0        1.031      1   1         RUNOFF         027
6 ADDHYD 4 045   7 5 3                                      1 1    1 1 1         ADDHYD         001
6 REACH  3 046   3   5       6200.0         1.2         1.51      1   1         REACH          022
6 RUNOFF 1 047       1         0.35        77.0        0.78                     RUNOFF         027
6 REACH  3 048   1   2       5100.0         2.0         1.5                     REACH          022
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SAMPLE TR20 MODEL INPUT FILE

```
6 ADDHYD 4 048    2 5 1                                         1      1    1         ADDHYD          001
6 RUNOFF 1 049        2          0.17          73.0          2.84                       RUNOFF          027
6 REACH  3 050    2   3        5500.0           3.0           1.5                       REACH           022
6 ADDHYD 4 050    3 1 2                                         1      1    1         ADDHYD          001
6 RUNOFF 1 051        1          1.25          79.0          1.01                       RUNOFF          027
6 ADDHYD 4 051    1 2 3                                         1      1 1 1         ADDHYD          001
6 RESVOR 2     07 3   1        5600.0                           1 1    1 1 1         RESVOR          026
6 RUNOFF 1 052        1           2.8          60.0          1.18                       RUNOFF          027
6 RUNOFF 1 053        2           2.2          60.0          0.90                       RUNOFF          027
6 ADDHYD 4 054    1 2 3                                                                 ADDHYD          001
6 REACH  3 055    3   4        3600.0          1.75          1.45                       REACH           022
6 RUNOFF 1 056        5           4.0          60.0          1.59                       RUNOFF          027
6 ADDHYD 4 057    4 5 6                                                                 ADDHYD          001
6 REACH  3 058    6   7       25000.0          1.75          1.45                       REACH           022
6 RUNOFF 1 059        1           6.1          60.0          1.43                       RUNOFF          027
6 ADDHYD 4 059    7 1 2                                                                 ADDHYD          001
6 DIVERT 6 060    2 1 3         600.0                        61.0                       DIVERT          010
6 DIVERT 6 061    3 4 5          94.0                        62.0                       DIVERT          010
6 DIVERT 6 062    5 6 7         170.0                        63.0                       DIVERT          010
6 DIVERT 6 063    7 1 2        1600.0                                                   DIVERT          010
6 REACH  3 064    1   2        9000.0           2.5           1.5                       REACH           022
6 RUNOFF 1 065        1          0.59          73.0          1.99                       RUNOFF          027
6 ADDHYD 4 065    2 1 3                                                                 ADDHYD          001
6 REACH  3 070    3   1       16200.0           2.0           1.5                       REACH           022
6 RUNOFF 1 071        2          1.42          72.0          2.30                       RUNOFF          027
6 ADDHYD 4 071    1 2 3                                                                 ADDHYD          001
6 RUNOFF 1 072        1          0.05          77.0          0.38                       RUNOFF          027
6 DIVERT 6 072    1 2 4         100.0                        73.0                       DIVERT          010
6 REACH  3 073    4   1        5700.0           2.0           1.5                       REACH           022
6 ADDHYD 4 073    1 3 4                                                                 ADDHYD          001
6 REACH  3 074    2   3        1200.0           0.7           1.4                       REACH           022
6 RUNOFF 1 075        1          0.04          77.0          0.31                       RUNOFF          027
6 ADDHYD 4 075    1 3 2                                                                 ADDHYD          001
6 DIVERT 6 076    2 1 3         240.0                        77.0                       DIVERT          010
6 REACH  3 077    3   2        4100.0           2.0           1.5                       REACH           022
6 ADDHYD 4 078    2 4 3                                                                 ADDHYD          001
6 REACH  3 079    1   2        1000.0           0.6          1.45                       REACH           022
6 RUNOFF 1 080        1          0.03          77.0          0.27                       RUNOFF          027
6 ADDHYD 4 080    1 2 4                                                                 ADDHYD          001
6 DIVERT 6 081    4 1 2         350.0                        82.0                       DIVERT          010
6 REACH  3 082    2   4        2600.0           2.0           1.5
6 ADDHYD 4 083    4 3 2
6 REACH  3 084    1   4        3500.0           0.5           1.5                       REACH           022
6 RUNOFF 1 085        3          0.20          77.0          0.68                       RUNOFF          027
6 ADDHYD 4 085    3 4 1                                                                 ADDHYD          001
6 DIVERT 6 086    1 3 4         660.0                        87.0                       DIVERT          010
6 REACH  3 087    4   1        1000.0           0.3           1.6                       REACH           022
6 ADDHYD 4 087    1 2 4                                                                 ADDHYD          001
6 RESVOR 2     06 4   5        5767.5                                                   RESVOR          026
6 DIVERT 6 088    5 7 6        1200.0                        89.0                       DIVERT          010
6 ADDHYD 4 089    6 3 1                                                                 ADDHYD          001
6 RESVOR 2     03 1   2        5765.0                           1      1 1 1         RESVOR          026
6 ADDHYD 4 090    2 7 1                                         1      1   1         ADDHYD          001
6 REACH  3 091    1   2        5800.0           2.0          1.51      1   1         REACH           022
6 RUNOFF 1 092        1          0.76          73.0          1.08                       RUNOFF          027
6 ADDHYD 4 092    1 2 3                                         1 1    1 1 1         ADDHYD          001
7 INCREM 6                       0.03                                                   INCREM          015
7 COMPUT 7 001    092             0.0           1.0          1.06 2  03   01         COMPUT          005
  ENDCMP 1                                                                              ENDCMP          012
7 INCREM 6                     0.0833                                                   INCREM          015
7 COMPUT 7 001    092             0.0           1.0          1.05 2  03   02         COMPUT          005
  ENDCMP 1                                                                              ENDCMP          012
  ENDJOB 2                                                                              ENDJOB          013
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